Morphological Fingerprint of New Rice Genotypes

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Abstract. The world's important food commodity is rice. This rice needs to be extended annually, but the production has not been able to meet the demands. The morphological parameters' improvement is the major aim of this breeding program. Morphological fingerprint is a unique pattern of traits which consists of a genotype for identification purposes and to detect genetic diversity as the basis of rice breeding. One of the obstacles which is faced in rice cultivation is that it has poor aeration which is caused by floods. Climate change affects the potential flooding in productive fields. The land optimization under the flooding needs to be supported by tolerant genotypes rice that are able to adapt and produced high yield. The importance of morphological fingerprint through evaluations of seventeen rice genotypes in a potentially flooded environment, would increase the efficiency of the breeding programs. The study of variability on yield and these components of rice genotypes showed a wide range of variation and specificity for all traits. The Pearson correlation coefficients for fifteen characters indicate that rice yield had a positive and significant correlation with culm diameter, biomass, and harvest time. The performance of rice genotypes had a significant negative correlation on 1000-grain weight and biomass.

1. Introduction
Rice is an essential food crop. Its demand will continue to increase in the future and will face many increasingly complex challenges, especially related to climate change [1,2]. Rice is the most important food crops that are grown globally [3]. Breeding program chooses not only a genotype with high productivity but also a complex of morphological traits. It is essential to characterize in detail these major rice genotypes through morphological fingerprint. The methods evaluate and characterize rice genotypes for its Distinctness, Uniformity, and Stability traits recommended for the rice crop [4]. The study to analysis variability among rice genotypes using morphological fingerprint can be potentially selected for development of new varieties [5].

Rice is traditionally cultivated in waterlogged conditions, and about 80% of the freshwater used in agriculture is for rice production [6]. Responses of plants to flood involve adaptive changes and/or deleterious effects [7]. Water stress has frequently illustrated the effect on plant’s growth inhibition [8].

Central Java is one of the main rice producers in Indonesia. Rice production in the last decade (2010-2019) ranged from 9,391,959 to 11,473,161 tons per year. Central Java has a harvested area that tends to be stable 1,678,479.2 - 2,010,464.8 ha. The main problem with rice cultivation is the risk of affected land and crop failures by flood. Affected land reaches an average of 2,558.44 ha in 2017-2018, with a maximum value of 16,644.60 ha in November 2017 ha and 15,234 ha in November 2018. Crop failure is one of the risks of rice cultivation that must be avoided. In 2017-2018 it was known that 530.24 ha...
was unavoidably experiencing crop failures, even more 3,158.40 ha in February 2017 and 2,882.48 ha in February 2018. Climate change in Central Java experienced significant changes, rainfall ranged from 5.09-410.21 mm (2017) and 1.00-429.88 mm (2018). Rainy days were highest in January 2017 (19.01 day) and February 2018 (19.62 day), while lowest in August 2017 (1.36 day) and July 2018 (0.37 day). Comparing the data on climate change (rainfall and rainy day), the crop failure problem, and the affected land at the same time. It can be concluded that they have a positive correlation. This also means that higher rainfall and rainy day can cause rice cultivation to have poor aeration so that it floods, and causing crop failure and affecting the land [9,10].

The actual risk of climate change is that it leads to low agricultural production and simultaneous crop failure [11]. The changes in rainfall patterns will have the most devastating impacts on agricultural production. Climate change negatively affects crop production and food security [12]. The strategy for overcoming problems in marginal land is to utilize plants that are tolerant of environmental stress. Efforts to utilize land that have the potential to be flooded can be done by assembling the promising rice genotypes that are resistant to flood stress.

Morphological data is particular visual evaluation to determine the characteristics of certain genotypes [13]. The morphological fingerprints are useful for assessed genetic variability within a given genotype [14]. Previous studies in lowland rice Asian countries has been conducted. It is to determine the genotypic character in an environment for the purpose of high grain yield [15,16]. Morphological characters related to adaptation to flood stress need to be observed, the previous results show that the roots and seed filling stages play an important role in getting high yields [17]. The rice characters of leaf length [18], biomass [19], productive tillers, and harvest time are also related to rice yield [20]. The purpose of this study was to determine the morphological fingerprint of flood tolerant rice genotypes with high yield.

2. Material and Methods

2.1. Study site

The study was conducted at Magelang, Central Java (7°27’51” N, 110°11’34” E) altitude of 430 m above sea level. This site was represented the main rice producers in Central Java, Indonesia, lowland rice area, and frequently flooded. The type of soil in field trials is Alluvial or silty clay. The soil consists of sand (21.14%), silt (30.08%), clay (48.79%), with pH H₂O 6.06, and pH KCl 4.29. The content of C-Organic low (1.68%) and N-Kjeldahl moderate (0.25%). This location has P₂O₅ (Olsen) 78.41 ppm, P₂O₅ HCl 25% very high (88.22 mg/100g), and K₂O HCl 25% high (43.01 mg/100g). The climatic conditions in the growing season during cultivation were average temperature (26.72°C), air humidity (56.81%), and air pressure (1009.81 mbar), respectively. Annual rainfall in this region is 27.45%.

2.2. Materials and design

The experiment of Oryza sativa L. was carried out in February-July 2019. The studies were comprised of seventeen rice genotypes. There are fifteen lines (GM 11, V11, V12, V12 Inpari, GM 28, GM 2, GM 8, Inpago 6 Mayangsari, Mutan Lampung Kuning, Mutan Rojolele 30 Pendek, Mutan Rojolele 30 Tinggi, Mutan V12T, Mutan Mayangsari, Mutan Lakatesan, Mutan Batan), and two varieties (Inpari 33, Inpari 30 Ciherang Sub 1). The rice lines are the advanced generation that already has stable properties to become promising commercial varieties.

The study was arranged in a randomized complete block design, with three replications. Each rice genotypes sowed in the nursery and transplanted in the fields at the age of 15 days. Each entry was transplanted in size of 5x5 m², plot to plot distance was kept at 0.5 m. Row to row and plant to plant spacing were maintained at 20x20 cm², two plants per holes. Common recommended agronomic practices for rice growing and control of pests/diseases in fields was done in the study site [21,22,23].

2.3. Morphological character measurements
Major phenotypic was evaluated on the entire population for quantitative and qualitative traits, according to the methodology Descriptors for wild and cultivated rice (Oryza spp.) [24]. Performed morphological fingerprint was taken for the following fifteen traits on root length, root volume, root dry weight, plant height, culm diameter, flag leaf length, flag leaf width, and biomass. Yield component characters consist of productive tillers, panicle length, grain fill per panicle, percentage of grain fill, 1000-grain weight, yield, and harvest time.

Rice qualitative traits are associated with the flood consists of culm lodging resistance and culm strength. The observation stage of these characters begins at harvest. Culm lodging resistance is characterized by scored at maturity based and degree of lodging. Culm strength is assessed by gently pushing the tillers back and forth at a distance of about 30 cm from the ground. This test gives some indication of the nature of rice stiffness and resilience.

2.4. Data analysis

All quantitative data from seventeen rice genotypes, containing three replications, were analysed its general mean among genotypes with GLM procedure. Significant differences (Alpha 0.05) between genotypes are indicated by different letters [25]. The statistical parameters of rice morphological were performed using the Statistical Analysis System version 9.1. [26]. Correlation coefficients for yield and related characteristics in seventeen genotypes were recorded and analysed in RStudio program.

3. Results and Discussion

3.1. Morphological character

| Genotypes             | Root length (cm) | Root volume (ml) | Root dry weight (g) |
|-----------------------|------------------|------------------|---------------------|
| GM 11                 | 21.38 Def        | 54.63 a          | 15.00 a             |
| V11                   | 21.16 De         | 41.87 bc         | 16.67 a             |
| V12                   | 21.62 c-f        | 47.28 ab         | 13.33 a             |
| V12 Inpari            | 19.97 F          | 40.08 bc         | 15.67 a             |
| GM 28                 | 20.29 F          | 42.00 bc         | 16.67 a             |
| GM 2                  | 20.89 Ef         | 47.37 ab         | 13.33 a             |
| GM 8                  | 23.96 Ab         | 36.53 c          | 13.33 a             |
| Inpago 6 Mayangsari   | 24.30 A          | 56.48 a          | 16.33 a             |
| Mutan Lampung Kuning  | 21.38 Def        | 53.70 a          | 17.00 a             |
| Mutan Rojolele 30 Pendek | 19.99 F      | 43.00 bc         | 16.67 a             |
| Mutan Rojolele 30 Tinggi | 23.14 a-d     | 56.03 a          | 14.00 a             |
| Mutan V12T            | 24.73 A          | 34.00 c          | 14.33 a             |
| Mutan Mayangsari      | 22.43 b-e        | 41.88 bc         | 14.00 a             |
| Mutan Lakatesan       | 23.41 Abc        | 42.37 bc         | 14.33 a             |
| Mutan Batan           | 20.76 Ef         | 40.33 bc         | 16.33 a             |
| Inpari 33             | 23.91 Ab         | 54.25 a          | 15.67 a             |
| Inpari 30 Cihang Sub 1| 21.73 c-f        | 49.20 ab         | 15.67 a             |

Significant differences (Alpha 0.05) between rice genotypes are indicated by different letters. During its life cycle, the rice obtains water by absorbing water from the environment, is influenced by the characteristics of plants and environmental factors (soil water content, temperature, and air humidity). Excess water is one of the main limiting factors in agriculture that can affect the growth process and crop production. Climate change can cause an abundance of water for plants. When this stress occurs, roots play an important role in plant adaptation by maximizing the root system.
Morphological fingerprint of rice genotypes was studied to observe genetic diversity assessment and identification of superior genotypes for crop improvement programs. Roots have an important role when plants respond in the adaptation process to water availability. The root morphological character needs to be evaluated as a plant's response to water abundance and to assess the plant's adaptability. Some morphological characters of roots observed to show plant resistance to excess water are root length, root volume, and root dry weight.

Seventeen rice genotypes showed root length characters, best on the Mutan V12T (24.73 cm) and Inpago 6 Mayangsari (24.30 cm). Inpago 6 Mayangsari (56.48 ml), Mutan Rojolele 30 Tinggi (56.03 ml), and GM 11 (54.63 ml) have the best root volume values. Root dry weight in general there are no significant differences between rice genotypes, that show the best potential are Mutan V12T (17.00 g), GM 28 (16.67 g), and Mutan Rojolele 30 Pendek (16.67 g) (Table 1).

Plants have a set of successful strategic adaptations to harsh environments. The characteristics of the roots is particularly crucial [27]. One method that is often used to see the plant's tolerance to environmental stress is to look at plant root growth. Root length indicates the length from the neck to the tip of the root. Tolerant plants of environmental stress, have the ability to adapt morphologically when conditions are unfavourable, plants will use more energy for root growth, compared to canopy growth [30]. The findings of other studies say an efficient root system will increase the rate of transport and water transported to the canopy, reduce water loss through the epidermis, and reduce the absorption of heat through rolling or folding the leaves. The degree of tolerance of plants to flooding depends on the type and stage of plant development at the time of inundation, the depth of the inundation given, and the duration of the flood [31].

| Genotypes              | Plant height (cm) | Culm diameter (mm) | Flag leaf length (cm) | Flag leaf width (cm) | Biomass (kg) |
|------------------------|-------------------|--------------------|-----------------------|----------------------|--------------|
| GM 11                  | 115.73 e          | 6.70 d             | 47.55 ab              | 1.89 a               | 3.30 a       |
| V11                    | 132.52 a          | 7.50 be            | 42.34 cd              | 1.26 f               | 2.77 a       |
| V12                    | 83.05 k           | 5.53 f             | 33.57 f               | 1.43 cde              | 2.57 a       |
| V12 Inpari             | 95.58 i           | 5.74 f             | 32.22 f               | 1.49 bc              | 2.77 a       |
| GM 28                  | 108.92 f          | 6.39 de            | 47.92 a               | 1.45 bcd             | 3.17 a       |
| GM 2                   | 118.97 d          | 6.32 e             | 46.98 ab              | 1.38 c-f             | 2.87 a       |
| GM 8                   | 99.18 h           | 6.09 e             | 38.67 e               | 1.40 cde             | 2.77 a       |
| Inpago 6 Mayangsari    | 121.35 c          | 6.13 e             | 30.50 f               | 1.56 b               | 2.47 a       |
| Mutan Lampung Kuning   | 121.98 c          | 8.02 a             | 44.01 bc              | 1.46 bcd             | 3.14 a       |
| Mutan Rojolele 30 Pendek | 126.78 b        | 7.60 b             | 47.43 ab              | 1.03 g               | 3.06 a       |
| Mutan Rojolele 30 Tinggi | 91.35 j          | 4.89 g             | 34.05 f               | 1.26 f               | 2.83 a       |
| Mutan V12T             | 130.53 a          | 8.00 a             | 31.00 f               | 1.37 c-f             | 2.90 a       |
| Mutan Mayangsari       | 121.07 c          | 7.22 c             | 40.08 de              | 1.31 ef              | 2.63 a       |
| Mutan Lakatesan        | 90.88 j           | 5.08 g             | 31.24 f               | 1.45 bcd             | 2.67 a       |
| Mutan Batan            | 102.60 g          | 4.94 g             | 32.93 f               | 1.41 cde             | 3.13 a       |
| Inpari 33              | 101.62 g          | 5.11 g             | 34.07 f               | 1.33 def             | 3.37 a       |
| Inpari 30 Ciherang Sub 1 | 102.35 g         | 4.91 g             | 41.65 cde             | 1.38 c-f             | 2.80 a       |

Significant differences (Alpha 0.05) between rice genotypes are indicated by different letters.

Morphological characters need to be known to find out the potential growth of rice genotypes. Plant height was determined from base of the shoot to the highest tip of panicle. The plant height character shows V11 (132.52 cm) and Mutant V12T (130.53 cm) has the highest value (Table 2).
Plant height is one of the key selection criteria for modern rice line development. Tall lines are useful in rice breeding programs for flood-prone areas. The disadvantage of the tall plant is interspecies shading, which brings about a decrease in photosynthetic efficiency when the light receptor receives solar energy infra the threshold [32].

Culm diameter in seventeen genotypes ranged from 4.89 mm (Mutan Rojolele 30 Tinggi) to 8.02 mm (Mutan Lampung Kuning). Leaves as an important rice character are known GM 28 (47.92 cm) has maximum value of flag leaf length, and Inpago 6 Mayangsari (30.50 cm) has the shortest leaf. The flag leaf width of all genotypes produced various values, from GM 11 (1.89 mm) to Mutan Rojolele 30 Pendek (1.03 mm). The biomass tested did not show significant differences, it appeared that the highest value was Inpari 33 (3.37 kg) and the lightest was Inpago 6 Mayangsari (2.47 kg) (Table 2).

Flooding is one of the major environmental stressors that has affected plant growth and development. Rice genotypes that have inundation stress tolerance can be used as an alternative or innovation for assembling rice varieties that are tolerant to flood stress. The greater flag leaf length had elongated panicle length and useful resulting in an increased number of grains in the panicle. This will ultimately improve the rice yield [33].

### 3.2. Yield component character

An important character of rice is number productive tillers. Genotypes that have the potential to produce high productive tillers are Mutan Rojolele 30 Tinggi (16.65), Mutan Mayangsari (16.37), and Mutan V12T (15.98). The lowest productive producer is GM 11 (10.55) (Table 3).

| Genotypes                  | Productive tillers | Panicle length (cm) | Grain fill per panicle | Percentage of grain fill | 1000-grain weight (g) |
|----------------------------|--------------------|---------------------|------------------------|--------------------------|------------------------|
| GM 11                      | 10.55 g            | 26.80 a             | 195.00 ab              | 79.80 cde                | 20.92 ab               |
| V11                        | 12.85 ef           | 23.60 def           | 216.93 a               | 82.58 cd                 | 26.29 a                |
| V12                        | 15.55 abc          | 21.37 hi            | 94.48 ef               | 89.68 a                  | 27.33 a                |
| V12 Inpari                 | 14.92 bcde         | 20.24 i             | 79.80 f                | 74.16 f                  | 23.17 ab               |
| GM 28                      | 13.93 de           | 25.56 b             | 177.95 b               | 80.76 cd                 | 27.17 a                |
| GM 2                       | 12.98 ef           | 24.06 c-f           | 156.33 c               | 75.81 ef                 | 27.33 a                |
| GM 8                       | 14.65 cd           | 23.03 efg           | 110.70 de              | 73.51 f                  | 25.33 a                |
| Inpago 6 Mayangsari        | 12.72 f            | 25.06 bc            | 111.12 de              | 65.03 g                  | 27.50 a                |
| Mutan Lampung Kuning       | 15.57 abc          | 25.36 bc            | 197.98 ab              | 80.86 cd                 | 23.67 ab               |
| Mutan Rojolele 30 Pendek   | 14.17 d            | 24.23 b-e           | 207.73 a               | 79.34 de                 | 17.50 b                |
| Mutan Rojolele 30 Tinggi   | 16.65 a            | 22.82 fg            | 110.93 de              | 88.13 ab                 | 22.50 a                |
| Mutan V12T                 | 15.98 ab           | 22.15 gh            | 182.60 b               | 81.04 cd                 | 23.33 ab               |
| Mutan Mayangsari           | 16.37 a            | 23.13 efg           | 145.70 c               | 84.52 bc                 | 27.33 a                |
| Mutan Lakatesan            | 15.95 ab           | 20.84 i             | 122.72 d               | 91.88 a                  | 26.83 a                |
| Mutan Batan                | 14.73 bcd          | 24.95 bc            | 104.47 de              | 91.06 a                  | 23.83 ab               |
| Inpari 33                  | 15.60 abc          | 23.42 efg           | 92.78 ef               | 88.91 ab                 | 24.17 ab               |
| Inpari 30 Ciherang Sub 1   | 14.42 ed           | 24.76 bcd           | 143.37 c               | 91.44 a                  | 27.67 a                |

Significant differences (Alpha 0.05) between rice genotypes are indicated by different letters.

High plant growth does not guarantee crop yield. Plant growth has a great influence on the relationship between panicle length and yield. Plants that grow well, can absorb nutrients in large quantities, and will affect the activity of photosynthesis which can increase growth and yield components [34]. The number of rice tillers formed is very closely related to the amount of grain to be produced. The problem that often occurs in flooded plant conditions is the obstruction of the basic needs...
of plants, such as the supply of oxygen, carbon dioxide, and sunlight, thereby reducing the number of rice tillers [35]. In the process of metabolism, oxygen plays an important role as a producer of energy in cells, so that when oxygen concentration is low in the root region it can cause disruption of metabolic activity and energy production [36].

A sustainable rice breeding program could be achieved through precise knowledge of genetic divergence for yield components. Rice genotyping under flood conditions can decrease the number of tillers. Increasing the number of tillers was also not expected, because it could affect the ability of rice in the formation of grain [37]. Panicle is the result of photosynthesis as a determinant of rice yield. Flood conditions can reduce yield by 52% due to a decrease in the number of tillers formed [38].

Panicle lengths of seventeen genotypes have various values, ranging from 20.84 cm (Mutan Lakatesan) to 26.80 cm (GM 11). The grain fill per plant was hand-threshed of all panicles. Grain fill per panicle is the yield component character that gets attention, V11 (216.93), Mutan Rojolele 30 Pendek (207.73), and GM 11 (195.00) has the best potential (Table 3). Grain fill per panicle character is one of the supporters of rice yield. Grain content also has an effect on crop yields [39].

The best wishes percentage of grain fill are Mutan Lakatesan (91.88), Inpari 30 Cihera Sub 1 (91.44), Mutan Batan (91.06), and V12 (89.68). The 1000-grain weight character in this study was found to be not significantly different, the best in Inpari 30 Cihera Sub 1 (27.67 g) and Inpago 6 Mayangsari (27.50 g) (Table 3).

The 1000-grain weight is one of the factors supporting grain yields. When the grain formed has a high content weight, it will have a high yield. The lack of sunlight due to fallen stems makes plants less optimum in photosynthesis. Low light produces a poor appearance of rice grains and can reduce the 1000-grain weight. The grain weight is related to consumer preference involving dimension of the grain [40,41]. The characteristics of rice grains play a key role for the choice and demand of rice consumers. These characteristics largely influenced by the genotype. The genetic potential of a genotype determines the diversity of future use [42].

3.3. Yield character of rice genotypes

Rice yield as an important character, assessed its potential quantity, the best are GM 8 (9.11 t/ha), Mutan Lampung Kuning (7.97 t/ha), and Mutan Rojolele 30 Pendek (7.92 t/ha). Harvest time of the seventeen genotypes showed no significant difference. The shortest plant ages were Inpari 33 (107 days after planting/dap), Inpari 30 Cihera Sub 1 (111 dap), and four genotypes have harvest time 114 dap age (GM 11, V12, Mutan Mayangsari, and Mutan Lakatesan) (Table 4).

Table 4. Yield characters of rice genotypes

| Genotypes               | Yield (t/ha) | Harvest time (dap) |
|-------------------------|--------------|--------------------|
| GM 11                   | 5.42 bcd     | 114 a              |
| V11                     | 6.33 bcd     | 118 a              |
| V12                     | 4.42 cd      | 114 a              |
| V12 Inpari              | 6.41 bcd     | 127 a              |
| GM 28                   | 7.67 ab      | 127 a              |
| GM 2                    | 6.97 a-d     | 123 a              |
| GM 8                    | 9.11 a       | 120 a              |
| Inpago 6 Mayangsari     | 4.36 d       | 116 a              |
| Mutan Lampung Kuning    | 7.97 ab      | 133 a              |
| Mutan Rojolele 30 Pendek| 7.92 ab      | 151 a              |
| Mutan Rojolele 30 Tinggi| 6.20 bcd     | 151 a              |
| Mutan V12T              | 6.34 bcd     | 130 a              |
| Mutan Mayangsari        | 6.44 bcd     | 114 a              |
| Mutan Lakatesan         | 6.31 bcd     | 114 a              |
Genotypes | Yield (t/ha) | Harvest time (dap) 
--- | --- | --- 
Mutan Batan | 6.51 bcd | 116 a 
Inpari 33 | 7.08 abc | 107 a 
Inpari 30 Ciherang Sub 1 | 6.90 a-d | 111 a 

Significant differences (Alpha 0.05) between rice genotypes are indicated by different letters.

Appearance physiological age of rice genotype is influenced by age of flowering. The faster of flowering plants has a positive correlation with harvest time. Plant age indicates that each genotype has a different level of responsiveness to the environment.

Determination of the age of rice harvest is from yellowing of leaves and rice panicles. The ripe phase of rice grain begins with milk cooking (the grain begins to fill with fluid like milk), the full-grain rice turns yellow and hard. Rice plants can be harvested when panicles are 80% yellowed and fully filled [38]. The age of rice harvest is influenced by the photosynthetic, it is more widely used for elongation of stems due to flooding, the results of photosynthetic used as flower formation are reduced [43].

3.4. Qualitative traits

Table 5. Qualitative traits

| Genotypes | Culm lodging resistance | Culm strength |
|---|---|---|
| GM 11 | Intermediate | Strong |
| V11 | Very strong | Strong |
| V12 | Strong | Strong |
| V12 Inpari | very strong | Strong |
| GM 28 | Strong | Strong |
| GM 2 | Intermediate | Strong |
| GM 8 | Very strong | Strong |
| Inpago 6 Mayangsari | Strong | Strong |
| Mutan Lampung Kuning | Very strong | Strong |
| Mutan Rojolele 30 Pendek | Strong | Strong |
| Mutan Rojolele 30 Tinggi | Very strong | Strong |
| Mutan V12T | Intermediate | Strong |
| Mutan Mayangsari | Intermediate | Strong |
| Mutan Lakatesan | Intermediate | Strong |
| Mutan Batan | Intermediate | Strong |
| Inpari 33 | Very strong | Strong |
| Inpari 30 Ciherang Sub 1 | Very strong | Strong |

Note: Culm lodging resistance: 5=intermediate (most plants leaning about 45°); 7=strong (most plants leaning about 20° from vertical); 9=very strong (all plants vertical); Culm strength: 7=Strong.

Rice qualitative traits are influenced by genetically and not easily influenced by the environment. Seventeen genotypes observed culm lodging resistance at maturity showed a diversity score. The intermediate characters (most plants leaning about 45°) are owned by GM 11, GM 2, Mutan V12T, Mutan Mayangsari, Mutan Lakatesan, and Mutan Batan. Strong culms (most plants leaning about 20° from vertical) are V12, GM 28, Inpago 6 Mayangsari, and Mutan Rojolele 30 Pendek. Very strong lodging resistance at maturity is known in seven genotypes V11, V12 Inpari, GM 8, Mutan Lampung Kuning, Mutan Rojolele 30 Tinggi, Inpari 33, and Inpari 30 Ciherang Sub 1 (Table 5).

Qualitative traits are essential for the description of rice. This characteristic is one of the studies which based on genetic diversity The breeding program needs the evaluated traits based on morphological descriptors [44,45]. The other research on culm found the rice straw is formed by
sheaths of leaves. Short culm forms are more resistant to lodging than tall plants. This trait can serve as an indicator for selection resistance to lodging [46].

3.5. Correlation coefficients for fifteen characters of rice genotypes

Correlation studies are enabled to understand the relationship between various characters as well as the direction of expected during evaluation for flood resistance. Correlation coefficients for fifteen characters indicated that rice yield had positively and significantly correlated (p<0.05) with culm diameter (0.047), biomass (0.262), and harvest time (0.191). The Pearson correlations measured the strength of the linear relationship between the variables. The most significant positive correlations and those influence each other are plant height and culm diameter (0.592). Grain fill per panicle to character has a significant positive correlation with several other characters, including plant height (0.434), culm diameter (0.345), flag leaf length (0.300), and panicle length (0.463). Meanwhile, the most significant negative correlation is 1000-grain weight and biomass (0.251). These traits may become significant predictors for improvement rice yield by evaluated these in flood stress (Figure 1).

Plant breeding programs requires genotypes diversity. The knowledge of the relationships between the characters can be extremely useful in the strategies development of germplasm management and selection programs. This information has been demonstrated in morphological fingerprinting [47].

![Figure 1](image.jpg)

**Figure 1.** Correlation coefficients for yield and related characteristics in seventeen rice genotypes

Note: x1=root length; x2=root volume; x3=root dry weight; x4=plant height; x5=culm diameter; x6=flag leaf length; x7=flag leaf width; x8=biomass; x9=productive tillers; x10=panicle length; x11= grain fill per panicle; x12=percentage of grain fill; x13=1000-grain weight; x14=harvest time; x15=yield (t/ha).

4. Conclusion

Rice is a major cereal crop. This study indicates the morphological fingerprints and extent of variability generated can be used successfully to develop new rice genotypes. The extensive diversity at morphological levels of genotypes will help the rice breeders to find out economically field crop traits. Rice that have good expectations with high yield and is supported by other morphological components are needed to overcome the flood stress. The challenge can be answer with character of new rice genotypes GM 8, Mutan Lampung Kuning, and Mutan Rojolele 30 Pendek for cultivation.

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