The characteristics of local rice varieties of tidal swampland in South Kalimantan

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Abstract. The local rice varieties of tidal swampland dominate paddy fields in South Kalimantan. Differences in varieties are found with various names as Siam, Bayar, Pandak, and Lemo. This paper reviews studies related to the local rice of tidal swampland in South Kalimantan. The paper aims to describe the agronomic and morphologic characteristics of the local rice varieties. Data obtained from research was carried out at acid sulfate soils of tidal swampland in South Kalimantan. Characterization of the local rice varieties is carried out based on the Standard Evaluation System for Rice IRRI on agronomic traits, morphological character, grain quality including Fe and Zn content in brown rice, abiotic and biotic stress plant. The observed characters showed that several local rice varieties of tidal swamplands had good or superior characters so that it can be used as crossing material in breeding programs to improve new varieties (HYV’s) that are adaptable in the soil problem and acceptable by farmers and consumers at tidal swamplands. The new HYV’s can also increase rice production and productivity and increase markets demand at tidal swamplands of South Kalimantan.

1. Introduction

Tidal swampland is one of the swamplands which is currently a mainstay for increasing rice production. One component of rice cultivation technology is the use of high yielding varieties (HYV’s). In relation to tidal swampland, the HYV’s meaning must be balanced with plant adaptation’s nature. Adaptation of rice plants in tidal swampland requires genetically tolerant plant characteristics such as acid soil (low pH) and iron toxicity.

In Indonesia, tidal swampland is estimated at 20.1 million hectares spread over four major islands, namely Kalimantan, Sumatera, Irian Jaya (Papua) and Sulawesi [1,2]. Various research results showed that tidal swampland could be developed into productive land for agriculture with proper land management and technological innovation, especially rice [3,4]. The utilization of tidal swamplands for agricultural development, especially rice by the local community began spontaneously. Reclamation and opening of tidal swampland first started in the area around Banjarmasin carried out by Banjar farmers since 1920. Around 65,000 ha of tidal swampland in South and Central Kalimantan had been reclaimed into paddy fields until 1965 [5].

Local varieties still dominate paddy fields in tidal swamplands. In the South Kalimantan tidal swamplands area is 191,740 ha out of 639,810 ha or around 30%. Of this area 146,612 ha have been cultivated, while the remainder has not been cultivated nor has been cultivated. This area is for paddy fields which are more dominated by local varieties [6]. In 2001 around 92.5% of the land was planted with rice, where once a year local rice varieties were dominant, which amounted to 96.24%, the remainder were planted with HYV’s twice a year. The average productivity of rice (local and superior
varieties) in 2000 was 3.08 t/ha [7,8]. The large percentage of local rice varieties planted is probably due to the high adaptability, and to the ease of cultivation at the farm level. According to [9], local varieties are favored by farmers because of several advantages, including easy access, minimal maintenance, and plants that are tall enough to be easily harvested using ani-ani tool.

The general definition of local rice varieties has a long life cycle (9 to 10 months seed to seed), low yield potential (2 to 3 t/ha¹), and required less fertilizer and pesticide. It is also adaptive to stress environments, higher price, easier cultivation, and more efficient. Cultivation of local varieties by returning organic matter to the soil means that it can maintain soil fertility. The existence of local rice varieties in tidal swampland because it is adaptable and acceptable. Adaptability factor is related to local rice’s ability to tolerate various abiotic factors of growth environment, such as low pH, iron toxicity, and nutrient deficiency. In contrast, the acceptability factor refers to farmer acceptance level due to various reasons such as agro-morphology, technical cultivation, and more expensive grain [10,11].

Farmers have long planted various local rice varieties in the tidal swampland of South Kalimantan. The varieties of Siam, Bayar, Pandak and Lemo are well-known local varieties. The Bayar variety group has been cultivated by tidal swamp farmers since 1920, while the Lemo variety around 1956 [5]. The Siam variety group is currently the most common name depending on the grain shape, cooking rice taste, farmer’s name or unique characteristics received by local farmers [10,12].

This paper reviews of studies related to local varieties of rice of tidal swampland in South Kalimantan. The paper aims is to provide a comprehensive overview on the empirical evidence for characterization of local rice varieties of tidal swampland in South Kalimantan.

1.1. Local Varieties of Tidal Swamp Rice in South Kalimantan

The local rice varieties of tidal swampland in South Kalimantan are inseparable from the early community’s history of land clearing. Around 1920 began the construction of a road that connects Banjarmasin city to Martapura city through peat land. The workers besides working for road construction also planted paddy along the road. Because grain yield was satisfying so that many migrants opened rice fields and in 1927 land along seven kilometers was open for paddy fields [5].

Paddy field that had been opened were originally called Bayar field, because the rice varieties planted were the Bayar varieties. The term tidal swamp paddy field around 1958 by the head of the opening center of the "Rice Project" in South Kalimantan. Since 1958 the name of tidal swamp paddy fields has become famous throughout Indonesia. Furthermore, segregation of local varieties Bayar shown up names of new local varieties, namely White Bayar, Yellow Bayar and Melintang Bayar. The naming of White Bayar and Yellow Bayar was related to the color of light yellow grain (white) and straw yellow. Description Bayar variety included long-duration 9-10 months, nurseries 4 to 5 months, photoperiod-sensitive varieties, sensitive to water stress, easy to thresh and fall, not drought-resistant, plant height 160 to 170 cm, ratio milled grain/grain yield about 65-70%; grain yields was 2.5 to 3.0 t/ha¹ [5,10].

Due to droughts, people began to look for short duration rice varieties. In 1942 Siam became known as a shorter variety than the Bayar variety. The term of Siam at the farmer is a slender and longer form of grain. In 1956 also known as Lemo variety and then known Pandak variety. The segregation of these local varieties at local the farmer level is varies and Siam variety has the most variations in the name. This variation in name can be based on farmer name, shape and color of grain, name of the area, and other attributes related to the variety. Farmers generally selected their rice plants while harvest by selecting panicles that are considered better than original plants [13,14].

The segregation of local Siam varieties gave rise to the names of Siam Halus (small), Siam Manangah (medium), and Siam Ganal (bold) varieties. This naming is associated with the grain form of varieties. Siam Halus was the most popular because is considered more delicious and the selling price is higher than other local rice varieties. The Siam Halus segregation gave rise to Siam
Karangdukuh. Siam Karangdukuh lasted long enough and spread widely in a farming community and then came to a new variety called Siam Unus which is a segregation of Siam Karangdukuh [15].

Siam Unus variety then became very popular in South Kalimantan people because of its small, slender grain shape, and translucency milled rice, the color of rice is very white with a delicious taste especially, and the highest selling price. The segregation of Siam Unus variety raise the varieties of Siam Unus Halus, Siam Unus Kuning, and Siam Unus Putih, all of which refer to the shape and color of the grain. Siam Unus Halus is furthermore popular among the farming community and consumers in South Kalimantan [10,15].

2. Characteristics of Local Rice Varieties of Tidal Swampland

Genetic erosion of local rice varieties will be increased if existing local rice varieties have not been conserved [16-18]. The local rice varieties, which has been cultivated in tidal swampland of South Kalimantan are still exist. Local rice adaptation is related to the ability of rice to grow and produce on tidal swampland. Many and varied local varieties found in tidal swampland indicated that the varieties have been adaptive to tidal swampland condition which generally has limitations compared to irrigated paddy fields. On the tidal swampland there are a variety of local varieties of rice. Local varieties that are widely known in the tidal swampland, for example in South Kalimantan are 'groups' of Siam, Bayar, Pandak, and Lemo varieties. The Siam variety group is most often found with many of names at the farmer level. This name variation can be based on grain form, rice flavor, farmers' names or special characteristics received by local farmers [13]. The Bayar variety has been cultivated by South Kalimantan tidal farmers since 1920, while the Lemo variety around 1956 [5]. Characterization of local rice varieties of tidal swamplands is carried out based on Standard Evaluation System for Rice by IRRI [19] on agronomic traits, morphological character, grain quality, abiotic and biotic stress.

The local farmers in South Kalimantan recognize and named the tidal swamp rice based on the appearance of the husk (lemma and palea) color. Genetically, the difference of husk color may indicate genetic plasticity, well known as phenotypic plasticity. In brief, phenotypic plasticity can be defined as the ability of individual genotypes to produce different phenotypes when exposed to different environmental conditions [20]. In other words, phenotypic plasticity can also define as a phenomenon in which a given genotype may develop different states of a character or group of characters in different environments [21]. Hence, it includes the possibility to modify developmental trajectories in response to specific environmental cues, and also the ability of an individual organism to change its phenotypic state in response to variations in environmental conditions [20]. According to Nayar [21], this phenomenon is controlled by the specific allele or gene related to the conditions. For instance, the plant height variations are controlled by a gene regulator, namely rice plasticity 1 (RPL1), which located on chromosome 6.

In the development of local rice, it is explained that local rice varieties that have not undergone purification are not uniform in appearance, because the population is heterozygous. Such local rice varieties have genetic characteristics with several different attributes, suggesting that their agronomic appearance is not uniform like superior varieties [18]. The local varieties were plant that were classified into sativa species. Domestication of Oryza sativa species had formed a population of rice genotypes that were very diverse and differ from one production center to another [22]. In cultivation crops systems intensively, the use of less pure varieties was not recommended, because their crop management complicates. Therefore, it was necessary to strive for the process of pure lines selection to extract components of the formation of local varieties with mature age uniformity.

2.1. Agronomic traits and morphological characters

The agronomic traits were characterized by local varieties of South Kalimantan tidal swamp rice such as plant height, number of tillers, panicle exsertion, seedling vigor, and plant duration. Plant height of local varieties of tidal swamp rice varies 105 to 180 cm and tiller number between 10 to 24
tillers. The panicle is generally well exerted and moderate grain thresh (6 to 25%). While the morphology characters, such as leaf, and leaf flag angle, length and width of the leaf and the flag leaf, stem angle, and others. The leaf angle was horizontal and the flag leaf angle was between intermediate to horizontal. There is no flag leaf angle as erect as any HYV’s varieties. Likewise, stem angle was generally intermediate (between erect to open). Some local varieties representing the Siam, Pandak, Bayar, and Lemo groups can be seen in Table 1.

The research results [23] showed that 44 local tidal swamp rice varieties of South Kalimantan showed that 100 grains-weight, yield per hill, plant height, number of productive tillers, number of grains per panicle, and panicle length showed wide variations in phenotype (Table 2). While the research results of [24] indicated that varieties that had quantitative characters were better compared by the population mean, but there were no differences in all qualitative characters, except for upper and lower leaf texture characteristics and range of grain yield 1.5 to 6.1 t.ha⁻¹. The characteristics of local varieties of South Kalimantan tidal swamp rice generally have the following characteristics [24-27]. The local rice varieties had various advantages, such as able to adapt in sub-optimal lands, suitable for planting in the tidal swampland and also could grow in the soil on rainfed land [28]. According to Constantino [29], the tillering ability is one of the quantitative traits that contributed positively to rice productivity (yield). In rice plants, the number of panicles is very dependent on the number of tillers. In other words, the higher number of tillers, the higher number of harvests produced. Hence, cultivars with the highest ability of tiller number are the main goal in breeding programs since the 18th century for the high yields [30].

Leaf angle was erect to intermediate; flag leaf angle was intermediate to horizontal, horizontal to descending, erect to intermediate, leaf length was 33 to 46 cm, flag leaf length was 24 to 36 cm, leaf width was 0.8 to 1.2 cm, flag leaf width was 0.8 to 1.2 cm, stem angle was erect to intermediate, tillering number was 7 to 19 tillers, productive tillers number was 5 to 17 tillers, panicle number was 6.4 to 37.7 panicles, mean 16.7 panicles, ligule was cleft; ligule length was 0.5 to 2.3 cm, grain was awn absent, slender, panicle was full exerted and compact, milled rice was small-slimer and translucent, plant height was 80 to 144 cm, grain yield per hill was 14.9 to 62.5 g average 27.2 g, 100 grain-weight was 1.40 to 2.90 g average 1.78 g, grain weight per panicle was 1.07 to 5.56 g average 2.89 g, grain weight per hill was 7.88 to 69.59 g average 32.38 g, grain number per panicle was 47.4 to 136.6 grains average 94.8 grains, filled grain number per panicle was 65.6 to 225.7 grains average 137.9 grains, panicle length was 17.8 to 27.4 cm average 22.4 cm, grain length was 7.14 to 9.98 mm average 8.37 mm; and grain width was 0.88 to 1.39 mm average 1.23 mm [25].

Tidal swamp rice cultivars showed a relatively low in phenotypic diversity, both the qualitative and quantitative traits. However, the secondary branches of panicle and awn distribution were part of the qualitative traits that indicate a high diversity index. Similarly, the grain ratio, the number of tillers, and the plant height also indicate the high diversity indices. The plant height and number of tillers are part of the quantitative traits that consider a primary contribution to the plant yield productivity [29,31]. With regards to farmers and consumer preferences, the grain shape is one of an important key in developing new rice cultivar for the tidal swamp areas. According to Calingacion [32] most of the local people of South Kalimantan are favorable to cultivate and consume the rice grain with a medium size, like Siam Saba and other Siam.

Research by Mursyidin [31] showed that the diameter of the stem or basal internode had a strong correlation with plant height and number of tillers, as well as panicle length. The larger-sized rice stem is also associated with the large size of panicles, as well as a higher number of grains per panicle [33]. Plant maturity is the most sought trait since the "green revolution" era for the development of the hybrid rice cultivars, around the 1960s [34]. Similarly, the grain ratio that represents the grain shape, is the main component in determining the grain weight and yields [35]. According to Calingacion [32], the grain shape is essential to consider in the program concerning the preferences of the local people and farmers. In South Kalimantan, for example, they have a very high preference (until 92.5%) for the local rice with a slender grain shape [36].
The tall and robust plants suitable for tidal swampland which were generally high inundation. In contrast, the exertion panicle made it easier for farmers to harvest using an *ani-ani* tool. A horizontal leaf angle may suppress the growth of weeds beneath it and thus, some local varieties of rice characteristics will reduce the weeding costs. Most of the varieties characterized were relatively resistant to lodging, such as Bayar Palas, Pandak Putih, Siam Unus, and Lemo Putih varieties. These included stems are big and strong enough to support plant growth. The range of basal stem diameter of local varieties was 4.9 to 8.9 mm. Vigor seedlings of local varieties were well exserted and determines the shape of rice grain-

| Characters            | Siam Unus | Pandak | Bayar Palas | Lemo Kwatik | Lakatan Gadur |
|-----------------------|-----------|--------|-------------|-------------|---------------|
| Plant height (cm)     | 142       | 121    | 140         | 182         | 149           |
| Tillering number      | 20        | 18     | 15          | 14          | 15            |
| Leaf length (cm)      | 58        | 44     | 46          | 44          | 47            |
| Leaf width (mm)       | 12        | 12     | 12          | 11          | 13            |
| Stem length (cm)      | 118       | 95     | 116         | 154         | 121           |
| Stem diameter (mm)    | 6.9       | 6.7    | 7.3         | 6.8         | 7.9           |
| Grain length (mm)     | 7.7       | 8.2    | 8.8         | 8.5         | 8.8           |
| Grain width (mm)      | 1.7       | 1.7    | 1.8         | 1.9         | 1.8           |
| Maturity (days)       | 291       | 305    | 305         | 272         | 295           |
| Lodging (%)           | 5         | 0      | 0           | 10          | 25            |

Source: Khairullah et al [37]

| Variable              | Phenotypic variance | Deviation Standard | Criteria of phenotypic variance |
|-----------------------|---------------------|--------------------|---------------------------------|
| 100 grain-weight      | 0.073               | 0.006              | Broad                           |
| Grain yield per hill  | 85.998              | 0.0206             | Broad                           |
| Plant height          | 134.346             | 0.2575             | Broad                           |
| Productive tiller numbers | 11.559          | 0.0755             | Broad                           |
| Grain number per panicle | 507.37           | 0.500              | Broad                           |
| Panicle length        | 4.55                | 0.047              | Broad                           |

Source: Saleh [23]

The emergence of phenotypic plasticity on the rice grain may also be related to the presence of transposon or transposable elements (TEs). According to Lisch [38], there are some TEs in rice that appear to regulate nearby genes by antisense transcription. For example, an active rice transposon named miniature Ping (mPing) is associate with the mutability of a slender mutation of the glume-the seed structure that encloses and determines the shape of rice grain [39].

The stem was strong but often lodging at harvest stage and the land was still flooding accompanied by a strong wind. Lodging plants between 0 to 40% depending on the condition of the land. The lodging was also supported by tall plants (120 to >130 cm). Nevertheless, high plant at was still considered quite profitable because it was easily harvested with an *ani-ani* tool and farmers did not bend in harvesting it [8]. Nevertheless, of course, it was not suffecient for harvesting using a sickle tool or combine harvester.

The well exerted of panicles so quickly the birds were attacked, but it was easy for farmers to harvest them with an *ani-ani* tool. The grain on the panicle is easy to thresh, so it was considered
suitable to be harvested with an ani-ani tool and threshed by traditional threshing. The drawback could reduce yield when harvested with a sickle. Harvesting could reach nine to 10 months from seed to seed. This was not profitable in terms of time efficiency, but the land had not been arranged because seeds must be transplanted twice to become large and robust.

The leaves were generally long, wide, and drooping. It could result in less sunlight distribution to the bottom, so the photosynthesis process was not perfect. On the other hand, this could suppress the growth of weeds at the bottom of the plant. Another flag leaf character that is not erect made it easier for bird attacks. Leaf-sheaths were somewhat spaced between leaves to reduce the attack of rice sheath blight [31,32,36]. Stems of plants were tall, broad, not compact with long internode. The conditions made plants easily lodged when exposed to the wind. Panicles were intermediate to long, open, a few secondary branches, and dropped in grain number per panicle was little.

2.2. The character of grain, milled grain, cooking rice

The grain was hairless or not awn at the tips. Farmers like it because it easy to thresh, but birds preferred it. The color of the grain was yellow or bright yellow. Some farmers like grain with bright yellow color because it was considered that its milled grain would be translucent too. The fur on the grain surface was glabrous. The local variety of Siam Wol had fur on its grain surface. Grain shape was generally slender (ratio > three lengths: width and medium. The slender shape was preferred because of higher selling prices, such as Siam Unus, Siam Mutiara, and Siam Karangdukuh varieties. However, the grain shape was medium to bold, usually had a high tolerance to environmental stress, such as Bayar Palas and Pandak varieties. Local varieties of milled rice were generally in shape slender to moderate, translucent and small endosperm chalkiness. The milled shapes and conditions were preferred by farmers whose prices were higher and more attractive. The milled grain of local varieties was easily broken, so this resulting in a low ratio grain and milled grain (40-50%).

The amount of grain per panicle and the high fertility of panicles can be improved. The selection of a number of these characters in the components forming local varieties with pure genotype/line for selection techniques is expected to enhance the appearance of the resulting lines. The best genotype is expected to have better productivity compared to the local varieties of origin.

The analysis of micro nutrient Fe and Zn contents Zn in whole brown rice of local varieties of rice showed in Table 3 and Table 4. The content of Fe and Zn varied greatly among local varieties. The Fe content of brown rice ranged from 11 to 83 ppm, where the lowest levels were indicated by Kutut variety (11 ppm Fe). The highest was shown by the Siam Pandak variety (83 ppm Fe). The highest frequency was 11 to 21 ppm Fe followed by 22 - 32 ppm Fe respectively with the frequency of 40.8% and 38.0%. It means that about 75% of local varieties tested for Fe content of brown rice were in the range of 11 to 32 ppm Fe. Zink (Zn) content of local varieties also varied significantly with a wide enough interval, which ranged 20 to 108 ppm Zn. The lowest level was shown by the Siam Unus Putih variety (20 ppm Zn) and the highest was shown by the Siam Panangah variety (108 ppm Zn).

Variation of Fe and Zn content of HYV’s or promising lines were not as comprehensive as local varieties. For HYV’s planted in the same acid sulfate tidal swampland, the lowest Fe content was indicated by the Kapuas variety (20 ppm Fe), and the highest was shown by Banyuasin (44 ppm Fe). In contrast, the highest Fe content of promising lines was shown by GH47 of 70 ppm Fe. The HYV’s or promising lines that had the lowest Zn content were GH 173 (28 ppm Zn), and the highest was shown by the Martapura variety (65 ppm Zn) [26,32]. The Fe and Zn are indicators of the nutritional quality of rice. Some local rice varieties contain high Fe and Zn in whole brown rice than existing HYV’s, it showed that these varieties could be used as a source of genes for rice improvement new varieties with high levels of Fe and Zn. Genetic factors required of a variety is that have the ability to take advantage of limited environment or capable take advantage of improved environment.
Table 3. Fe and Zn content (ppm) of local varieties, HYV’s and promising lines

| No. | Local varieties          | Fe content (ppm) | Local varieties          | Zn content (ppm) |
|-----|--------------------------|------------------|--------------------------|-----------------|
| 1   | Siam Pandak              | 83               | Siam Panangah            | 108             |
| 2   | Siam Wol                 | 70               | Siam Sabar               | 103             |
| 3   | Bayar Palas              | 67               | Siam Puntal              | 98              |
| 4   | Siam Panangah            | 54               | Siam Perak               | 89              |
| 5   | Siam Lantik              | 47               | Siam Halus               | 89              |
| 6   | Pandak Putih             | 45               | Siam Brandal             | 88              |
| 7   | Pandak Kembang           | 43               | Siam Karangdukuh Kuning  | 85              |
| 8   | Pandak Arjuna            | 43               | Siam Perak Halus         | 84              |
| 9   | Siam Ganal               | 40               | Siam Ganal               | 79              |
| 10  | Siam Unus Putih          | 39               | Siam Arjuna              | 63              |
| 11  | Pandak Manggar           | 38               | Siam Perak Ganal         | 51              |
| 12  | Unus Gampa               | 36               | Siam Randah Kuning       | 49              |
| 13  | Pal Sebelas              | 35               | Siam Pontianak Halus     | 46              |
| 14  | Siam Karangdukuh         | 34               | Siam Tanggung            | 44              |
| 15  | Unus Organik             | 33               | Siam Lantik              | 43              |
| 16  | Siam Sebelas             | 32               | Unus Organik             | 42              |
| 17  | Siam Adus                | 32               | Pandak Kembang           | 39              |
| 18  | Siam Ubi                 | 31               | Kawi                     | 38              |
| 19  | Lemo Putih               | 31               | Lakatan Pacar            | 37              |
| 20  | Siam Perak Ganal         | 31               | Pirak                    | 37              |
| 21  | Lakatan Siam             | 30               | Siam Adus                | 37              |
| 22  | Siam Pangling            | 29               | Lakatan Gadur            | 36              |
| 23  | Siam Puntal              | 29               | Raden Rata               | 35              |
| 24  | Siam Sabar               | 29               | Siam Pontianak Tinggi    | 35              |
| 25  | Jurut                     | 28               | Siam Unus Kuning         | 34              |
| 26  | Siam Pontianak Halus     | 28               | Palon                    | 34              |
| 27  | Siam Karta               | 27               | Siam Puntal              | 34              |
| 28  | Siam Pontianak Tinggi    | 27               | Pandak                   | 34              |
| 29  | Lakatan Gadur            | 26               | Siam Teladan             | 34              |
| 30  | Pirak                    | 26               | Siam Pandak              | 34              |
| 31  | Siam Halus               | 26               | Siam Klubut              | 33              |
| 32  | Siam Birik               | 25               | Siam Lantik Putih        | 33              |
| 33  | Lakatan Pacar            | 25               | Lakatan                  | 33              |
| 34  | Siam Arjuna              | 25               | Siam Kretik              | 33              |
| 35  | Siam Perak               | 25               | Bayar Palas              | 33              |
| 36  | Bayar Papuyu             | 24               | Siam Randah              | 32              |
| 37  | Bayar Pahit              | 24               | Mendawak                 | 32              |
| 38  | Siam Palas               | 23               | Siam PX                  | 31              |
| 39  | Lakatan Putih            | 23               | Adil Kuning              | 31              |
| 40  | Siam Karangdukuh Kuning  | 23               | Lemo Kwatik              | 31              |
Genetic diversity is valuable in supporting breeding programs, as well as the conservation of natural resources [40]. According to Frankham [41], genetic diversity can be measured based on morphological, biochemical, and molecular types of information. The result of Yustisia [42] showed that the contents of Fe and Zn of brown rice varied from 5 HYV’s (Ciherang, Widas, IR64, Cisokan, and Cimelati) which were planted in inceptisol soil (10.84 to 19.80 ppm Fe and 19.64 to 24.55 ppm Zn). The highest Fe content was indicated by Widas variety, and the lowest was Cisokan. The highest Zn content was shown by Ciherang variety and the lowest was by Cimelati. Research by [43] showed that the average Fe and Zn content in HYV’s were 11.7 ppm Fe and 23.9 ppm Zn. The information of Fe and Zn content from the local rice varieties was very useful for breeders to be used as material for parents to improve a new high yielding variety with high Fe or Zn content. Likewise, it could be used as a food ingredient to meet Fe and Zn mineral intake needs.

In general, milled rice of local varieties was non-waxy. Consumers favored it because it was suitable for consumption with gravy and fried rice. At the farmer level, it was considered to delay hunger because it was digested longer. The problem was that if the rice were cold, it would become quite hard. Delicious rice depend on taste and side dishes. Furthermore, the milled rice color was clear white or dull white. Clear white milled rice was preferred than dull-white because it made more appetite. Good eating quality of local varieties like Siam Unus Putih, Siam Karangdukuh and so on were the characteristics of the varieties that were very popular with local farmers and consumers. The characteristics of this varieties must emerge if we want to improve new HYV’s in the tidal swamplands of South Kalimantan in addition to their adaptability to soil problem conditions.

2.3. Resistance of local rice to pests and diseases

The results of testing resistance to pests and diseases in several local varieties, as many as 22 varieties were selected, have resistance to pests and diseases to be used as a genetic source for rice improvement in tidal swampland and back swampland (Table 4). The resistance to pest tested was brown planthopper biotype 1, while the diseases tested were leaf blast ras 002 and brown spot. The resistance to pests and diseases is one of the important characteristics of this local variety. Other factors that also determine community preferences for rice varieties in swamps are high yield potential, market demand, plant age, plant height, and pest and disease resistance [44,45].

Furthermore, Prayudi's research [47] showed that tidal swamp local rice was tolerant to rice sheath blight (Table 5). The regeneration ability of local varieties of rice hills after the hill died from being attacked by pathogens showed that Lemo, Bayar Pahit, Bayar Palas and Karangdukuh varieties were able to regenerate well after the dead hills were attacked by pathogens. The remains of the dead plants show little and no sclerotium formation. This greatly reduced the number of initial inoculums for the subsequent inoculation of pathogens naturally, so that the new tillers that grew could be free from attack by pathogens in the form of sclerotium.
ability is not as good as the first four local varieties. On the remains of dead plants a sclerotium is formed, it was likely that the newly grown puppies can be attacked by pathogens originating from the sclerotium, although Suparyono [48] stated that the role of the sclerotium as the initial inoculum was insignificant. The dead hills of IR36 variety were no longer able to regenerate, and sclerotium was formed in the remains of dead plants. It was suspected that local tidal rice varieties had the ability to inhibit the sclerotium formation process.

Table 4. Resistance to insect and disease of several local rice varieties of tidal swampland

| Local Varieties | Pest | Diseases |
|-----------------|------|----------|
| Badagai         | (R) brown planthopper biotype 1 | (MR) leaf blast 002 |
| Isip            | (R) brown planthopper biotype 1 | (MR) brown spot |
| Lakatan Jambu   | (MR) brown spot                  | (MR) leaf blast 002 |
| Latur           | (R) brown planthopper biotype 1, | (MR) leaf blast ras-002 |
| Palui           | (R) brown planthopper biotype 1, | (MR) brown spot |
| Sabat Jalan     | (R) blas leaf 002                | (R) leaf blast 002, (R) brown spot |
| Sanggul         | (R) blas leaf 002                | (R) brown spot |
| Sasak Jalan     | (MR) leaf blast 002              | (R) leaf blast 002 |
| Siam Arjan      | (R) leaf blast 002               | (R) leaf blast 002 |
| Siam Bamban     | (R) leaf blast 002               | (R) leaf blast 002 |
| Siam Cinta      | (R) leaf blast 002               | (R) leaf blast 002 |
| Siam Pandak     | (R) leaf blast 002               | (R) leaf blast 002 |
| Siam Sanah      | (R) leaf blast 002               | (R) leaf blast 002 |
| Siam Unus       | (R) leaf blast 002               | (R) leaf blast 002 |

R = resistance, MR = moderately resistance
Source: ISARI [46], Prayudi [47]

Table 5. Ability of regeneration, formation, number, and size of sclerotium of several local rice varieties after a dead hill was attacked by *Rhizoctonia solani*

| Varieties       | Regeneration Ability | Formation of Sclerotium | Sclerotium number | Sclerotium size (mm) |
|-----------------|----------------------|-------------------------|-------------------|----------------------|
| Lemo            | Good                 | (-) No                  | 0                 | 0                    |
| Bayar Pahit     | Good                 | (-) No                  | 0                 | 0                    |
| Bayar Palas     | Good                 | (-) No                  | 0                 | 0                    |
| Karangdukuh     | Good                 | (-) No                  | 0                 | 0                    |
| Pandak          | Intermediate         | (+) Little              | 5.6               | 1.3                  |
| Siam Unus       | Intermediate         | (+) Little              | 4.8               | 1.0                  |
| IR36 (check)    | dead                 | (++) A lot              | 11.6              | 2.6                  |

Table modified
Source: Prayudi [47]

Morphologically, there were differences between local rice varieties and high yielding variety rice types. The number of tillers per hills of local varieties was generally between 6-8 stems, while for high yielding variety it reached more than seven stems. The higher tillers number per hills in high yielding variety rice caused sunlight not to reach the basal of the rice stems, so that the humidity around the basal of the plants in high yielding variety was higher than local varieties. This really helps the development of disease in local varieties. The stem segments in the fourth and / or fifth sheath were open (not completely covered by the leaf sheath), so that the development of disease symptoms
stops in the third or fourth sheath of local rice. Meanwhile, in high yielding variety rice, all stem segments were covered by leaf sheath (leaf sheath continuous) so that the development of disease symptoms could reach the leaf sheath. This caused disease development in local rice varieties to be slow, so that the intensity of leaf blight in local rice is lower than in high yielding variety rice. In the local varieties, pathogen (*R. solani*) was little or even not able to form sclerotium in the leaf sheath, the number of tillers was less, and the fourth or fifth leaf sheaths were not interconnected. This was what caused disease progression to be slower than what happens in a high yielding variety rice so that it had better regeneration ability. The combination of these characteristics caused tidal swamp local rice to be tolerant or resistant of rice leaf sheath blight.

### 2.4. The character of tolerance to iron toxicity

The local varieties characterized in the field visually did not show any iron toxicity symptoms. This might be due to the seedling old (about four months) so that the seedlings when planted were strong and large. Besides, it was also possible that conditions in paddy fields had begun to drop in the level of dissolved iron in the soil so that seedlings were protected from iron toxicity. The research results by Khairullah [49] showed that local varieties had a mechanism for a tolerance iron toxicity. Screening for a tolerance of iron toxicity of 130 local varieties from tidal swamplands of South Kalimantan and South Sumatera showed different variations. Soil iron content of 156 ppm Fe; while iron content in ground water was initially high (0.44 me L⁻¹) then decreased along with the time (13th week = 0.06 me L⁻¹). Consecutive iron content in ground-water during at the third week to fourteen week were shown in Table 6.

Rice varieties with a high tolerance to water stress will be quickly selected by farmers, while the yield potential is relatively low. Adaptation of rice varieties is a major factor in tidal land, so that the superior variety can be adopted by farmers [45]. In addition to good adaptability in the tidal swampland, local varieties in general has good consumer preferences and market demand. Those advantages influenced the sustainability of the rice variety in swamps [50].

| Week | Fe content in ground water (me.L⁻¹) |
|------|------------------------------------|
| 3    | 0.44                               |
| 4    | 0.71                               |
| 5    | 0.13                               |
| 6    | 0.01                               |
| 7    | 0.008                              |
| 8    | 0.079                              |
| 9    | 0.006                              |
| 10   | 0.56                               |
| 11   | 0.34                               |
| 12   | 0.08                               |
| 13   | 0.06                               |
| 14   | 0.47                               |

**Source:** Khairullah *et al* [37]

Scoring symptoms of iron toxicity indicated that there was considerable variation between seedling old. One week of seedlings old showed higher resistance, then followed by seedlings two and three weeks old. There was 35 local varieties tolerance to iron toxicity at one week old, while 29 resistant varieties were at two weeks old and finally only 20 resistant varieties (Table 7). The observations every week for four weeks showed the response of seedlings old of local varieties were not consistent with iron toxicity (Figure 1). Several local varieties showed recovery to grow at older plants, but in
other varieties the older varieties showed increased of iron toxicity symptoms [37]. It is assumed that younger plant seedlings will be stronger and able to adapt in suppressing Fe entering the plant tissue compare to older plant seedlings. Therefore, it is often recommended to plant rice in paddy fields using young seedlings. The younger seedlings, apart from being more tolerant of Fe toxicity stress, are also have more tillering ability so that the grain yield is also higher than older seedings.

The higher tolerance level of local varieties of iron toxicity was thought to be caused by genetic factors that can control the iron entering plant tissue. This can be seen from the Margasari variety whose tolerance level was not different from Siam Unus Putih. Margasari variety is the result of a cross between local variety of Siam Unus and high yielding variety of Cisokan. It was suspected that the high tolerance for iron toxicity of Margasari was mostly contributed by Siam Unus variety. Other research by Khairullah [49] showed that Fe-soil concentrations of local varieties and check variety were about three to four times the critical limit, where Bayar Palas variety (1,126.1 ppm), Cisokan variety (1,113.7 ppm) and IR64 variety (1,076.0 ppm Fe) showed concentrations of Fe-soil higher than other varieties. This means that the potential for iron toxicity stress was very large so that rice plants showed symptoms of iron toxicity, even though the tolerance levels were different. Rice varieties differ in their ability to release oxygen from roots to oxidize Fe$^{2+}$ in the rhizosphere as a way to protect plants from iron toxicity.

Response of local variety seedlings old to Fe toxicity

| Week | Seedling old 1 week | Seedling old 2 week | Seedling old 3 week |
|------|---------------------|---------------------|---------------------|
| I    | 36                  | 2.4                 | 2                   |
| II   | 2.5                 | 4.4                 | 2                   |
| III  | 3.5                 | 1.8                 | 3                   |
| IV   | 4.5                 | 2.8                 | 5                   |

Figure 1. Response of local varieties seedling at 1, 2, 3 weeks old to iron toxicity on observations of weeks I, II, III, and IV. Source: Khairullah et al [37]

Besides having high adaptability, the local varieties are also adaptive in the land with extreme conditions, both high acidity or low soil and water pH [51]. On the other hand, the program of achieving self-sufficiency in food by increasing production and increasing the area of rice planting, encourage the use of superior and high-quality and certified varieties [52]. The program is in contrast to promote the cultivation of local rice varieties, such as Siam Unus and others. Therefore, some improvements in yield productivity are needed for the local rice varieties to meet national and regional needs.
### Table 7. Fe toxicity tolerance of local varieties of tidal swampland in acid sulfate soils.

| No. | Local varieties                  | Seedling old |
|-----|----------------------------------|--------------|
|     |                                  | 1 week | 2 weeks | 3 weeks |
| 1   | Siam Perak                       | +      | +       | +       |
| 2   | Siam Randah Putih                | +      | +       | +       |
| 3   | Pal Enam                         | +      | +       | +       |
| 4   | Pal Sebelas                      | +      | +       | +       |
| 5   | Lakatan                          | +      | +       | +       |
| 6   | Raden Rata                       | +      | +       | +       |
| 7   | Kawi                             | +      | +       | +       |
| 8   | Siam Puntal                      | +      | +       | +       |
| 9   | Siam Randah Kuning               | +      | +       | +       |
| 10  | Pirak                            | +      | +       | +       |
| 11  | Pandak Kembang                   | +      | +       | +       |
| 12  | Palon                            | +      | +       | +       |
| 13  | Bayar Palas                      | +      | +       | +       |
| 14  | Unus Organik                     | +      | +       | +       |
| 15  | Siam Pontianak Halus             | +      | +       | +       |
| 16  | Siam Lantik                      | +      | +       | +       |
| 17  | Selumbung                        | +      | +       | +       |
| 18  | Siam Rata                        | +      | +       | +       |
| 19  | Bonai                            | +      | +       | +       |
| 20  | Siam Karta                       | +      | +       |         |
| 21  | Putih Rampak                     | +      |         |         |
| 22  | Petek                            | +      |         |         |
| 23  | Siam Pangling                    | +      |         |         |
| 24  | Siam PX                          | +      |         |         |
| 25  | Siam Brandal                     | +      |         |         |
| 26  | Siam Perak Halus                 | +      |         |         |
| 27  | Unus Gampa                       | +      |         |         |
| 28  | Siam Tanggung                    | +      |         |         |
| 29  | Siam Halus                       | +      |         |         |
| 30  | Kutut                            | +      |         |         |
| 31  | Siam Pontianak Tinggi            | +      |         |         |
| 31  | Adil Kuning                      | +      |         |         |
| 32  | Pandak                           | +      |         |         |
| 33  | Siam Karangdukuh Kuning          | +      |         |         |
| 34  | Siam Gumpal                      | +      |         |         |
| 35  | Siam Arjuna                      | +      |         |         |
| 36  | Siam Unus Kuning                 | +      |         |         |

(*') score: 1-3 (moderate to highly tolerance) IRRI [19]

Source: Khairullah et al. [37]

### 3. Conclusions

The local rice varieties which were observed had some superior characters on agronomic traits, morphological characters, Fe and Zn content in whole brown rice, good eating quality, resistance to pest and disease, and tolerance to high levels of soil and water Fe. The local varieties that have been identified and have superior characteristics can be as cross-breeding materials on the rice breeding program to improve a new high yielding varieties (HYV’s) which are adaptable at the soils and
acceptable by farmers at tidal swamplands. The new HYV’s can increase rice production and productivity and are favored by farmers and markets at tidal swamplands especially in South Kalimantan.

Authors contribution
IK: main contribution, analyzed and interpreted data, and wrote the manuscript. MS, and M: members contribution, prepared some of the data.

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