Akta Agrosia

Agronomic Performances of Rice Lines on Non-Tidal Swampland

Mohammad Chozin*, Sarina Silalahi, Masdar, and Sumardi
Department of Crop Production, Faculty of Agriculture, University of Bengkulu
Jl. WR Supratman, Kandang Limun, Bengkulu 38120, Indonesia

ARTICLE INFO

Keywords:
F4 lines
growth and yield
rice landrace
Swampland
plant maturity

Article history:
Received: Feb 24, 2019
Accepted: Jun 23, 2019

*Corresponding author:
E-mail: mchozin@unib.ac.id

ABSTRACT

A successful rice production on swampland would require a planting material from high yielding varieties adaptated to the swampy ecosystem. This study was carried out to compare the growth and yield characteristics of five rice lines and a check variety as grown on non-tidal swampland. The lines were F4 generation of bulk selection from the crosses involving Bengkulu swamp rice landraces (Hanafi Putih, Tigo-tigo, Harum Curup, and Lubuk Durian) and high yielding varieties for the irrigated field (Sidenuk and Bestari). The trial was conducted on a shallow non-tidal swampland with stagnant inundation no more than 50 cm in depth often occurred during the plant life cycle. The lines and the check variety (Inpara 4) were arranged in a randomized complete block design with three replications. Observations were made for the agronomic performances of the plant, including plant height, total tiller number clump^{-1}, effective tiller number clump^{-1}, heading date, maturity date, panicle length, grain number panicle^{-1}, 100-grain weight, and grain yield clump^{-1}. Significant variation among the genotypes was found for all observed traits. On average, the evaluated lines showed comparable growth and yield performances to the check variety. Tigo-tigo × Bestari was the tallest line and potential for medium depth swampland. This line showed good overall agronomic performances and yielded relatively higher than the check variety, but delayed in attaining maturity. For shallow swampland, Hanafi Putih x Sidenuk exhibited the most potent line by having good overall agronomic and yield performances, except late in maturity. For early maturing line, Lubuk Durian x Hanafi Putih showed its potential for shallow swampland. Although this line was not the best, it showed better overall agronomic performances than the check variety.

INTRODUCTION

Rice serves as the staple food for most Indonesian with the annual consumption per capita around 124.9 kg of milled rice (PUSDATIN, 2016). With improving production technology, the existing rice fields can produce sufficient food supply for the current population. Nevertheless, such situations would be hard to maintain in the future as the demand for rice would steadily increase along with the population growth, while the areas for rice production tends to decline due to land conversion to non-agricultural uses (Irawan, 2016; Purbiyanti *et al.*, 2017).

The non-tidal swamplands in Indonesia cover more than 13.3 million hectares (Nugroho *et al.*, 1992), comprising shallow swampland (4.17 million hectares), medium depth swampland (6.07 million hectares), and deep swampland (3.04 million hectares) (Widjaja-Adhi *et al.*, 1992). The development of non-tidal swamplands

ISSN: 1410-3354 / e-ISSN:2615-7136

Cited this as: Chozin, M., S. Silalahi, Masdar, and Sumardi. 2019. Agronomic performances of rice lines on non-tidal swampland. Akta Agrosia 22(1):1-6 .

for crops production is lagging far behind those upland or irrigated land.

Ar-Riza (2011) noted that about 1.35 million hectares of non-tidal swampland had been opened and used for agricultural activities, but only 134.14 hectares were used intensively for rice production with twice planting in a year. On average, however, the rice productivity on these areas was only ranged from 2 ton.ha^{-1} to 4 ton.ha^{-1} (Hairmansis *et al*. 2013). Non-tidal swampland is mainly characterized by low soil pH, low soil fertility (Puspitahati, 2015), high iron concentration (Sahrawat, 2004), and unpredictable seasonal flood (Irmawati *et al*., 2015). Despite these inherent physicochemical limiting factors for crop production, swamplands have been set as the food barn of the future for maintaining Indonesia's food sufficiency and food security (BALITTRA, 2012).

Among the food crops, rice is considered as the most adaptable to swampy conditions as compared to the other food crops. However, not all rice varieties are economically feasible for production under swampy agroecosystem (Nassir and Ariyo, 2011). In addition to high yielding potential, the rice varieties for swampland production should be devised by sufficient adaptability to various abiotic *stresses, including tolerance to submergence (*Sakagami and Kawano, 2011) *and iron toxicity* (Sahrawat, 2010). As is commonly known that grain yield of rice is the resultant product of various other agronomic traits and strongly affected by the environment. A breeding program aimed at the development of new rice variety especially adapted to swampland conditions, therefore, should not simply be focused on the grain yield but also involve simultaneous selection covering the important agronomic performances (Norain *et al*., 2014). This study was performed to evaluate the growth and yield performances of five lines bred and selected for high yielding and well adapted to swampland agroecosystem.

MATERIALS AND METHOD

The trial was conducted in 2017 on the shallow swampland of the Faculty of Agriculture, University of Bengkulu ($\pm$ 10 m asl). The land was characterized by inceptisol type of soil with the pH ranged from 4.5 to 5 and peat thickness less than 50 cm. Stagnant inundation up to 50 cm often occurred during the plant growth period. A randomized complete block design (RCBD) with three replications was employed to allocate the F_4 lines of five crosses (Hanafi Putih × Sidenuk, Tigo-tigo × Harum Curup, Harum Curup × Sidenuk, Lubuk durian × Hanafi Putih, and Tigo-tigo × Bestari) and a check variety (Inpara 4) on 2.5 m x 2.5 m experimental plots. Hanafi Putih, Tigo-tigo, Harum Curup, and Lubuk Durian are Bengkulu swamp rice landraces; Sidenuk and Bestari are high yielding varieties developed by Indonesian National Nuclear Energy Agency (BATAN) for the irrigated field; while Inpara 4 is swamp rice variety developed by Indonesian Center for Rice Research (ICRR).

A no-tillage system was adopted for land preparation while existing vegetations were sprayed using herbicide and immersed in the soil. Seedlings of 20 days old from each genotype were transplanted to the assigned experimental plot at 25 cm x 25 cm planting space. Basal fertilizers consisted of Urea (75 kg ha^{-1}), SP-36 (100 kg ha^{-1}) and KCl (50 kg ha^{-1}) were applied in next day of transplanting. Supplementary urea (75 kg ha^{-1}) was added at heading stage. Weed and pest controls were performed as necessary.

Samples of 10 plants from each experimental plot were randomly selected for the observations of plant height, total tiller number clump^{-1}, effective tiller number clump^{-1}, heading date, maturity date, panicle length, grain number panicle^{-1}, 100-grain weight, and grain yield clump^{-1}. The collected data were subjected to analysis variance in accordance with the RCBD and, as applicable, the least significant difference (LSD) at 5% probability level was used for the mean separation among the genotypes.

RESULTS AND DISCUSION

Plant growth and development

The mean performances of the six genotypes for the growth and developmental traits are displayed in Figure 1. All lines, except Lubuk durian × Hanafi Putih, showed significant taller plant stature than Inpara 4 (Figure 1a). Tigo-tigo × Bestari (118.6 cm) exhibited as the tallest line, followed by Tigo-tigo × Harum Curup (108.3 cm) and Hanafi Putih × Sidenuk (105.5 cm). With respect to the tillering ability, Hanafi Putih × Sidenuk had the highest total tiller number clump^{-1}(35.7), while the remaining lines produced a comparable tiller number to Inpara 4 (26.7), namely Tigo-tigo × Harum Curup (30.9), Harum Curup × Sidenuk (30.1), Lubuk durian × Hanafi Putih (25.8), and Tigo-tigo × Bestari (30.3) (Figure 1b).

Heading date represents a developmental switch for the transition from vegetative to reproductive phases. The earlier heading was found on Harum Curup × Sidenuk (85.8 DAP) and Lubuk durian × Hanafi Putih (84.8 DAP) and showed no significant difference to Inpara 4 (93.0 DAP) (Figure1c). Late heading, on the other hand, was observed on Hanafi Putih × Sidenuk (106.7 DAP), Tigo-tigo × Harum Curup (109.5 DAP), and Tigo-tigo × Bestari (109.3 DAP). Moreover, a consistent pattern of differentiation among the genotype was found for maturity date, where Harum Curup × Sidenuk (106.7 DAP) and Lubuk durian × Hanafi Putih (109.6 DAP) showed no significant difference to Inpara 4 (119.2 DAP) with regard to earlier in attaining plant maturity (Figure 1d). Again, Hanafi Putih × Sidenuk (145.3 DAP), Tigo-tigo × Harum Curup (143.7 DAP), and Tigo-tigo × Bestari (139.6 DAP) took a longer period to reach the maturity state.

Grain yield and its contributing traits

Figure 2 depicts the mean performances for grain yield and the contributing traits. For the effective tiller number clump^{-1} (Figure 2a), Hanafi Putih × Sidenuk (34.1) was the only line having a significantly higher number than Inpara 4 (24.5), as found for total tiller number clump^{-1}. The rest of the lines having effective tiller ranged from 24.9 to 30.4, however, showed no significant difference to Inpara 4. Two groups of panicle length were observed among the genotypes. Harum Curup × Sidenuk (17.8 cm) and Lubuk durian × Hanafi Putih (18.1 cm) showed no significant different to

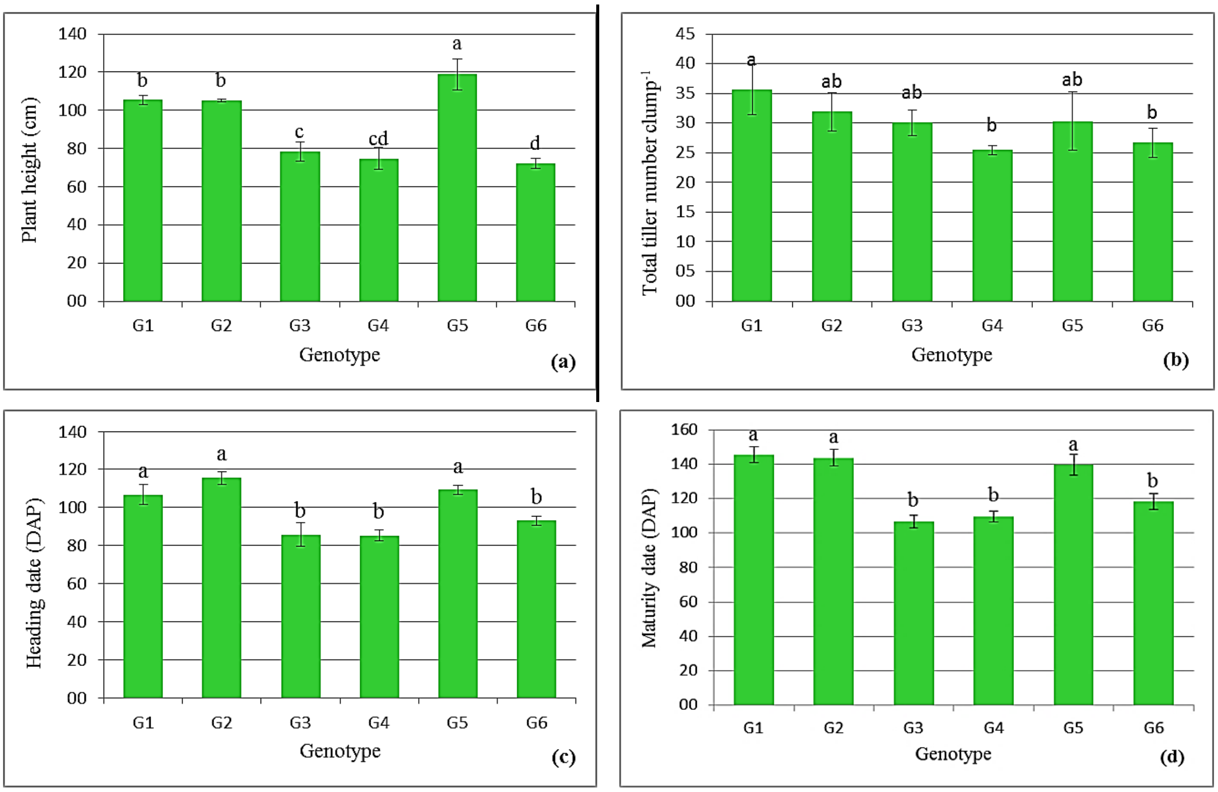

Figure 1. Mean performances growth and development of six swam rice genotypes on non-tidal swamp; G1= Hanafi Putih × Sidenuk, G2=Tigo-tigo × Harum Curup, G3=Harum Curup × Sidenuk, G4=Lubuk durian × Hanafi Putih, G5= Tigo-tigo × Bestari, and G6=Inpara 4; Means of the same trait marked with the same letter do not differ significantly on LSD test at 5% probability level

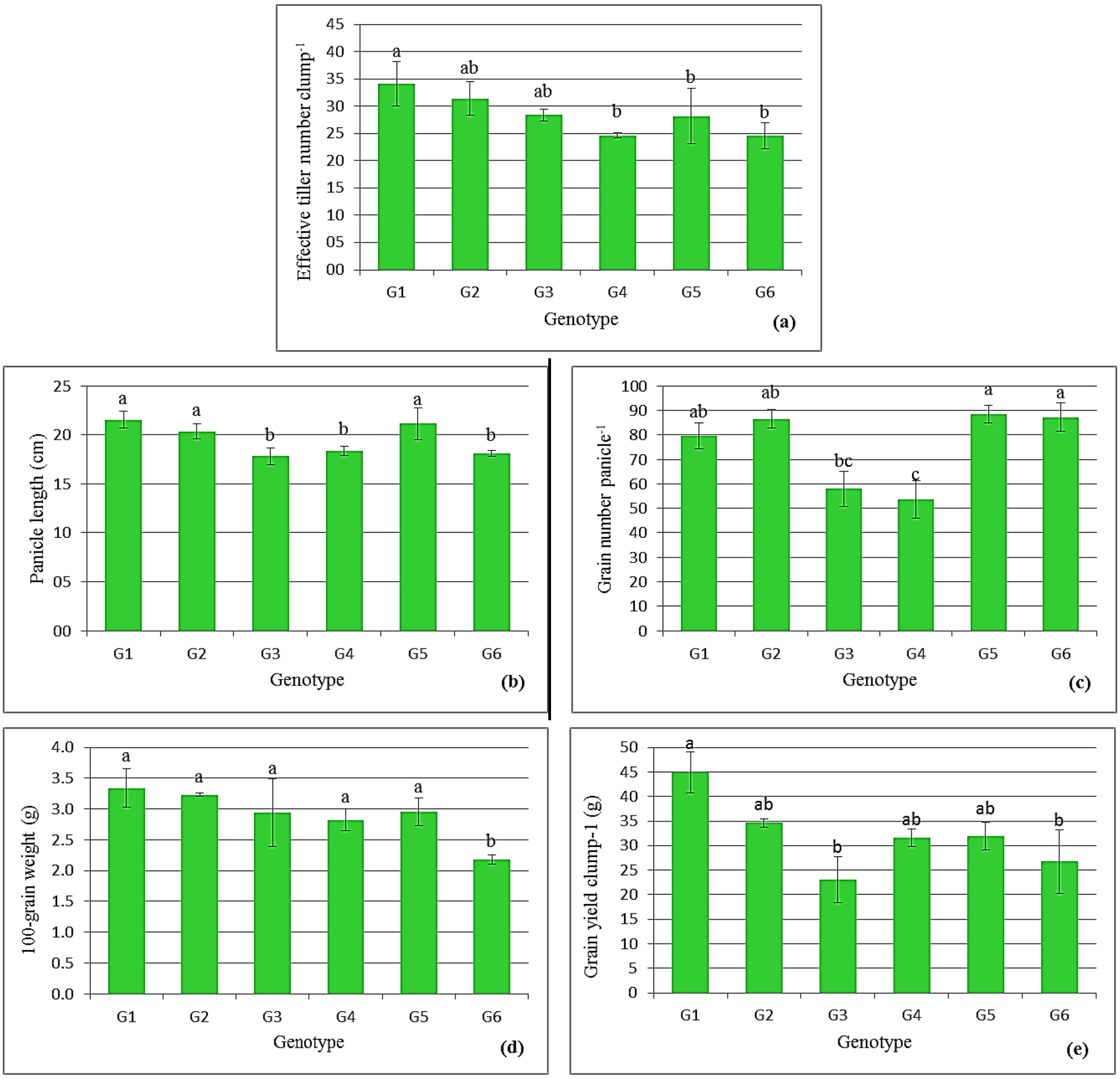

Figure 2. Mean performances of grain yield and the contributing traits of six swam rice genotypes on non-tidal swamp; G1= Hanafi Putih × Sidenuk, G2=Tigo-tigo × Harum Curup, G3= Harum Curup × Sidenuk, G4=Lubuk durian × Hanafi Putih, G5= Tigo-tigo × Bestari, and G6=Inpara 4; Means of the same trait marked with the same letter do not differ significantly on LSD test at 5% probability level

Inpara 4 (18.1 cm), while Hanafi Putih × Sidenuk (21.6 cm), Tigo-tigo × Harum Curup (21.1 cm), and Tigo-tigo × Bestari (21.1 cm) had significantly longer panicle than those three genotypes.

Based on the grain number born on a panicle (Figure 2c), only Harum Curup × Sidenuk (53.7) and Lubuk durian × Hanafi Putih (53.7) showed significantly lower than Inpara 4 (87.2). In addition, no significant difference to Inpara 4 was found on Hanafi Putih × Sidenuk (79.5), Tigo-tigo × Harum Curup (86.6), and Tigo-tigo × Bestari (88.6). For the grain size, all lines were significantly larger than the check variety, as indicated by their 100-grain weight (Figure 2d). The range of 100-grain weight for the lines was between 2.9 g and 3,3 g, while Inpara 4 was only 2.2 g. For the grain yield clump^{-1}, Hanafi Putih × Sidenuk (45.0 g) was the only line significantly outperformed Inpara 4 (26.7 g), while the remaining lines were felt between these two genotypes.

Non-tidal swamplands, also known as inland swamplands or fresh-water swampland, can be classified into three typologies based on the height and duration of the inundation, namely: 1) shallow swampland, characterized by inundation less than 50 cm in depth for 1-3 months; 2) medium swampland, characterized by inundation 50 cm to 100 cm in depth for 3-6 months; and deep swampland, characterized by inundation > 100 cm in depth for > 6 months (Waluyo and Jamhari, 2013). Among these typologies, deep swampland is the least utilized rice production, unless during the prolonged dry season (Djafar, 2013). Accordingly, shallow and medium swamplands are the most prominent targeted areas for swamp rice production and breeding.

For medium swampland, the rice genotypes having tall stature would have the advantage of enhancing the crop's ability to avoid submergence in the areas with a higher depth of inundation (Ram *et al*., 2009). In this evaluation, Tigo-tigo × Bestari would be the most potential for varietal development such an ecosystem, as characterized by tall stature. This line also had the good tillering ability, long panicle, high number of grain panicle^{-1}, and large grain size, although the obtained grain yield clump^{-1} was not the highest. The major drawback of this line was late in attaining heading and maturity stages. It has been commonly found that taller plant tended to have delayed generative and maturity stages (Mustafa and Elshikh, 2007; Babu *et al*., 2012).

The remaining lines were categorized as semi-dwarf based on their plant height and made them more suitable for a shallow swampland. Among the lines, Hanafi Putih × Sidenuk showed the best for overall agronomic performances, except heading date and maturity date. This line was characterized by medium tallness, high tillering ability, high tiller fertility, long panicle, high number of grain panicle^{-1}, large grain size, and high grain yield clump^{-1}. For earlier maturity, Lubuk durian × Hanafi Putih would be the most potent line for swallow swampland as it had better overall agronomic performances than the check variety, including the grain yield performance.

CONCLUSION

This study revealed the existence of variation among the genotypes for the observed agronomic performances. Three lines showed their potential for different non-tidal swampland typology. Tigo-tigo × Bestari was the tallest line and potential for medium depth swampland. Although delayed in attaining maturity, this line showed good overall agronomic performances and had relatively higher grain yield than the check variety., Hanafi Putih x Sidenuk exhibited the most potent line for shallow swampland by having good overall agronomic and yield performances, except late in maturity. For early maturing line, Lubuk Durian x Hanafi Putih showed its potential for shallow swampland. Although this line was not the best, it showed better overall agronomic performances, including grain yield, than the check variety. As the grain yield is the most important trait in rice production, further development of the potential lines should be taken through yield-based selection, either directly or indirectly, under the targeted swampland typology.

REFERENCES

Ar-Riza, I. 2011. Teknologi inovasi mengubah rawa lebak menjadi lumbung pangan berkelanjutan. Sinartani 41: 5-6.

Babu, V R., K. Shreya, K.S. Dangi, G. Usharani, and A.S.Shankar. 2012. Correlation and path analysis studies in popular rice hybrids of India. Int. J. Sci. Res. Publ. 2(3): 1-5.

BALITTRA. 2012. Swamp land as barns for the future. Indonesian Research Institute Swampland for Agriculture. Agency for Agricultural Research and Development.

Djafar, Z. R. (2013). Kegiatan agronomis untuk meningkatkan potensi lahan lebak menjadi sumber pangan. Jurnal Lahan Suboptimal 2(1): 58-67. [In Indonesian with English abstract].

Hairmansis, A., H. Aswidinnoor, B. Suprihatno, W.B. Suwarno, and W.B. Suwarno. 2013. Yield and grain quality of ten promising rice breeding lines for tidal swamp areas. J. Agron. Indonesia 41(1): 1-8.

Irawan, B. 2016. Konversi lahan sawah: potensi dampak, pola pemanfaatannya, dan faktor determinan. Forum Penelitian Agro Ekonomi 23(1): 1-18. [In Indonesian with English abstract].

Irmawati, H. Ehara, R.A. Suwignyo, and J.I.Sakagami. 2015. Swamp rice cultivation in South Sumatra, Indonesia. Trop. Agric. Dev. 59(1): 35-39.

Mustafa, M.A. and M.Y. Elsheikh. 2007. Variability, correlation, and path coefficient analysis for yield and its components in rice. Afr. Crop Sci. J. 15(4): 183-189.

Nassir A L and O.J. Ariyo. 2011. Genotype x environment interaction and yield-stability analyses of rice grown in tropical inland swamp. Not Bot Horti Agrobo. 39: 220-225.

Norain, M.N., A. Shamsiah, R.H. Abdul, A.H. Nor, A.M. Haslinda, and W.A. Wan Aminuddin. 2014. Correlation analysis on agronomic characters in F2 population derived from MR64 and Pongsu Seribu 2. J. App. Sci. Agric. 9(18): 143-147.

Nugroho, K., A. Paidi, W. Wahidin, H.S. Abdulrachman, and I.P.G. Widjaja-Adhi. 1992. Peta areal potensial untuk pengembangan pertanian lahan pasang surut, rawa, dan pantai. Proyek Penelitian Sumberdaya Lahan. Pusat Penelitian Tanah dan Agroklimat, Bogor.

Purbiyanti, E., M. Yazid and I. Januarti. 2017. Konversi lahan sawah di Indonesia dan pengaruhnya terhadap kebijakan Harga Pembelian Pemerintah (HPP) gabah/beras. Jurnal Manajemen dan Agribisnis 14(3): 209-2017. [In Indonesian with English abstract].

PUSDATIN (2016). Outlook komoditas pertanian: Padi. Pusat Data dan Informasi Pertanian. Kementerian Pertanian Republik Indonesia. 103 p. [In Indonesian]

Puspitahati. 2015. Karakteristik Lahan Rawa Lebak Desa Pelabuhan Dalam Kecamatan Pemulutan Kabupaten Ogan Ilir. Prosiding Seminar Nasional Lahan Suboptimal 2015, Palembang 8-9 Oktober 2015, pp. [In Indonesian with English abstract].

Ram, P.C., M.A. Mazid, A.M. Ismail, P.N. Singh, V.N. Singh, M.A.Haque and B.B. Singh. 2009. Crop and resource management in flood-prone areas: farmers' strategies and research development. Proceedings Natural Resource Management for Poverty Reduction and Environmental Sustainability in Fragile Rice-Based Systems, Los Baňos (Philippines), International Rice Research Institute, pp. 82-94.

Sahrawat, K.L. 2004. Iron toxicity in wetland rice and the role of other nutrients. J. Plant Nutr. 27 (8):1471–1504

Sahrawat K.L. 2010 Reducing iron toxicity in lowland rice with tolerant genotypes and plant nutrition. Plant Stress 4: 70-75.

Sakagami J.I. and N. Kawano. 2011. Survival of submerged rice in a flood-prone region of West Africa. Tropics 20: 55-66.

Waluyo, W. and S.Djamhari. 2013. Sifat Kimia Tanah Dan Kesesuaian Lahan Pada Masing -masing Tipologi Lahan Rawa Lebak Untuk Budidaya Tanaman Padi, Kasus Di Desa Tanjung Elai, Ogan Komering Ilir. Jurnal Sains dan Teknologi Indonesia, 13(3).204-209. [In Indonesian with English abstract].

Widjaja-Adhi, I.P.G., K. Nugroho, D.S. Ardi, and A.S. Karama. 1992. Sumberdaya lahan rawa Potensi, keterbatasan, dan pemanfaatan. In. Partohardjono, Sutjipto P. dan M. Syam dan Mahyuddin. (editor). Risalah Pertemuan Nasional Pengembangan Pertanian Lahan Pasang Surut dan Lebak. Puslitbangtan. Cisarua, 3-4 Maret 1992. p 19-38. [In Indonesian]