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Research Article

Characteristics and land suitability of newly established rice field in Lesung Batu Muda, Rawas Ulu, Musi Rawas, South Sumatera

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Abstract: Rice field has a strategic function because it is the main provider of food for the population of Indonesia. The data of the land use for the rice field in Indonesia showed that around 41% in Java Island. Agricultural technology at the level of industry experienced rapid progress, but the technology implementation at the level by farmer is relatively slow. Increased production of rice in Indonesia was reported of less than 1% per year. The research aimed to study the characteristics and land suitability of newly established rice field in Lesung Batu Muda, Rawas Ulu, Musi Rawas, South Sumatera. There were two soil land unit that were tested included water availability, rooting medium, level of erosion, soil chemical properties and land preparation. The results of the study showed that newly established rice fields in Lesung Batu Muda, Rawas Ulu, Musi Rawas, South Sumatera could be used to open new rice fields by planting twice a year. In opening new rice fields, the application of organic matter and creation of terracing on sloping areas were needed

Keywords: *newly established rice fields, organic matter, rooting media, soil chemical, South Sumatera*

Introduction

Rice (*Oryza sativa* L.) is a staple food of more than 50 % of the world's population (Fageria, 2007). Rice is produced in at least 95 countries across the globe and provides a staple food for more than half of the world's current population (Maclean et al., 2002; Coats, 2003). As population increases over this century, the demand for rice will grow to an estimated 2000 million metric tons by 2030 (FAO, 2002). Meeting this 35% increase in demand will require significant improvements in the rice production. However, achieving these improvements will be a challenge as the future climate changes and water scarcity increases (Ladha et al., 2009). Rice is the main staple food crop in Asia, which accounts for about 90% of global rice production. The irrigated rice covers half of the rice-growing area and accounts for about 75% of total rice production (Maclean et al., 2002). Continuous rice cultivation with two and occasionally three crops per year is common in tropical Asia. Rice in rotation with other crops, particularly wheat (*Triticum aestivum* L.), is common in subtropical Asia (Ladha et al., 2009), and the rotation of maize (*Zea mays* L.) with irrigated rice is increasing in importance in Asia (Ali et al., 2008). Fertilizer use has contributed to increasing production of rice-based systems since the Green Revolution. The effective use of supplemental nutrients remains is vital for the increases of the production of rice and associated cereal staples to meet the rising demand of food security and political stability.

The conversion of agricultural land to public facilities resulting in the opening of new rice fields for crops cultivation. Food durability program need to be implemented simultaneously consisting of agricultural land conversion, opening new rice fields and agricultural intensification. Presently, the technological application could be in a form of increasing land productivity and maintaining environmental quality. Food durability contains broad aspects, including the ability of food supply both from within and from outside the country. An effort in achieving food durability is widely focused on increasing the independence in self-sufficiency of food, especially rice. The problems of soils of the dry land outside Java island, especially Oxisols and Ultisols, are nutrient deficiency, especially phosphate, soil acidity, Al and Fe toxicities, and low organic matter content. These problems had to be seen in the transition of dry land to newly established rice fields. The research aimed to study the characteristics and land suitability of newly established rice field in Lesung Batu Muda, Rawas Ulu, Musi Rawas, South Sumatera

Materials and Methods

The study of newly established rice fields was held in a dry land, Lesung Batu Muda, covering an area of 215 ha. The soil of the study area has a solum depth of more than 50 cm. This research was held by descriptive-exploratory methods. Determination of sample points used purposive sampling method by taking 12 sample points that were divided into 2 units of land map. Land characteristics observed in this study included slope, erosion, rooting media, and water availability.

The water availability was obtained by precipitation data from 2006 to 2012. Parameters of rooting media consisted of soils texture, rough material and effective soil depth. Soil texture was measured with a hydrometer method in the laboratory. Rough material and effective soil depth were directly observed in the field. The level of erosion was predicted by looking at the surface of the sheet erosion, rill erosion and gully erosion in the field. Parameters of land preparation consisted of rocks at the surface and rock outcrops. The rock at the ground level may disrupt the process of land management. The rock outcrop is exposed on the surface of the land, which is a part of the large rocks under the soil. Chemical analysis of the soil measured included pH (pH meter method), CEC (Elektrometric method), total N (Micro Kjeldahl method), available P (Olsen method), and available K (Ammonium acetate method at pH 7). Maps were prepared through direct observation in the survey area and actual measurements at each point. Observation, description, and classification of soil profiles in the survey area were based on the same criteria. The map boundaries were delineated in accordance with the classification of the same soil. Characterization of sample points was based on observation in the field and laboratory.

Results and Discussion

Lesung Batu Muda is one of the villages in Musi Rawas district that consists of landscapes such as low land areas dominated by rubber trees. The type of the soil is red-yellow podzolic that is characterized by a thick solum. The soil in this village has a pH of 4.2 to 6.5 so that it can be cultivated for plantation.

Average precipitation in the year 2006 to 2012 in the District of Musi Rawas showed that wet season occurred from October to April and the dry season occurred in May to September (Figure1). Based on climate classification of Oldeman, the temperate within the area in Lesung Batu Muda is classified as type B (7^{th} to 9^{th} months of rain), thus, it supports the newly established rice fields. Based on the slope and the topography of the 12 sampling points, 2 soil land units (SLU) were obtained, with the results of land suitability characteristics shown in Table 2 and Figure 2.

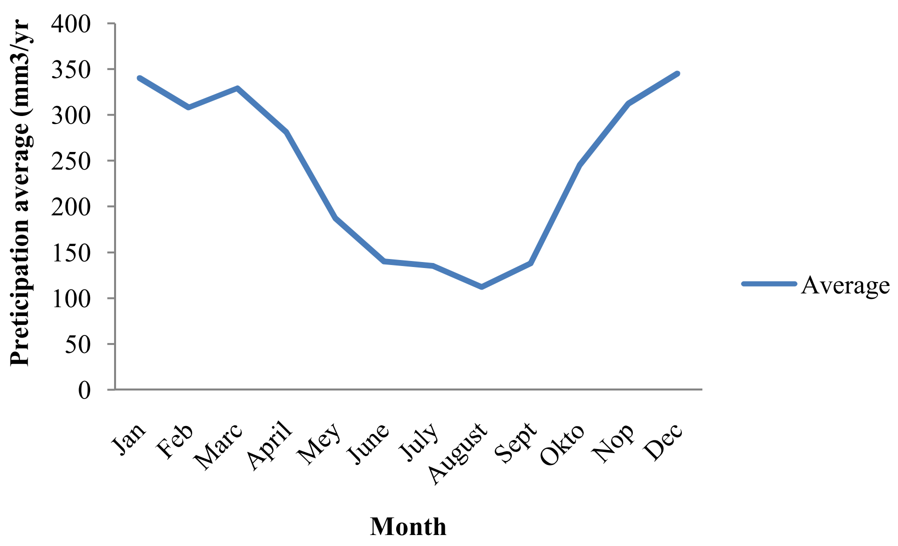

Figure 1. Average precipitation in the District of Musi Rawas (2006 to 2012)

Table 2. Characteristics of the newly established rice fields in Lesung Batu Muda, Rawas Ulu, Musi Rawas, South Sumatera.

Variable	**SLU 1**				**SLU 2**			
	Results	**P**	**I**	**A**	**Results**	**P**	**I**	**A**
Drainage	B	S1	-	S1	B	S1	-	S1
Texture	H	S1	-	S1	H	S1	-	S1
Rough material	24.2	S3	PT	S3	39.7	S3	PT	S1
Solum	50.7	S1	-	S1	50.8	S1	-	S1
Slopes (%)	7.7	S3	TR	S1	2.6	S1	-	S1
Rocks at the surface (%)	3.12	S1	-	S1	3.75	S1	-	S1
Rock outcrops (%)	2.5	S1	-	S1	3.5	S1	-	S1
CEC	36.4	S1	-	S1	47.2	S1	-	S1
pH	5.3	S1	-	S1	5.3	S1	-	S1
Organic matter (%)	0.28	S3	BO	S2	0.34	S3	BO	S2
P-available (%)	42.4	S1	-	S1	52.4	S1	-	S1
K-available (%)	0.36	S1	-	S1	0.28	S1	-	S1
N-total (%)	0.01	S3	BO	S2	0.02	S3	BO	S2

Treatment: A: Actually, I: Inputs, P: Potential, H: Smooth, S1: Highly suitable, S2: Moderately suitable, S3: Marginally suitable, N: Not suitable, PT: land management, BO: Input organic matter, PD: Drainage Improvements, TR: the making of the terrace.

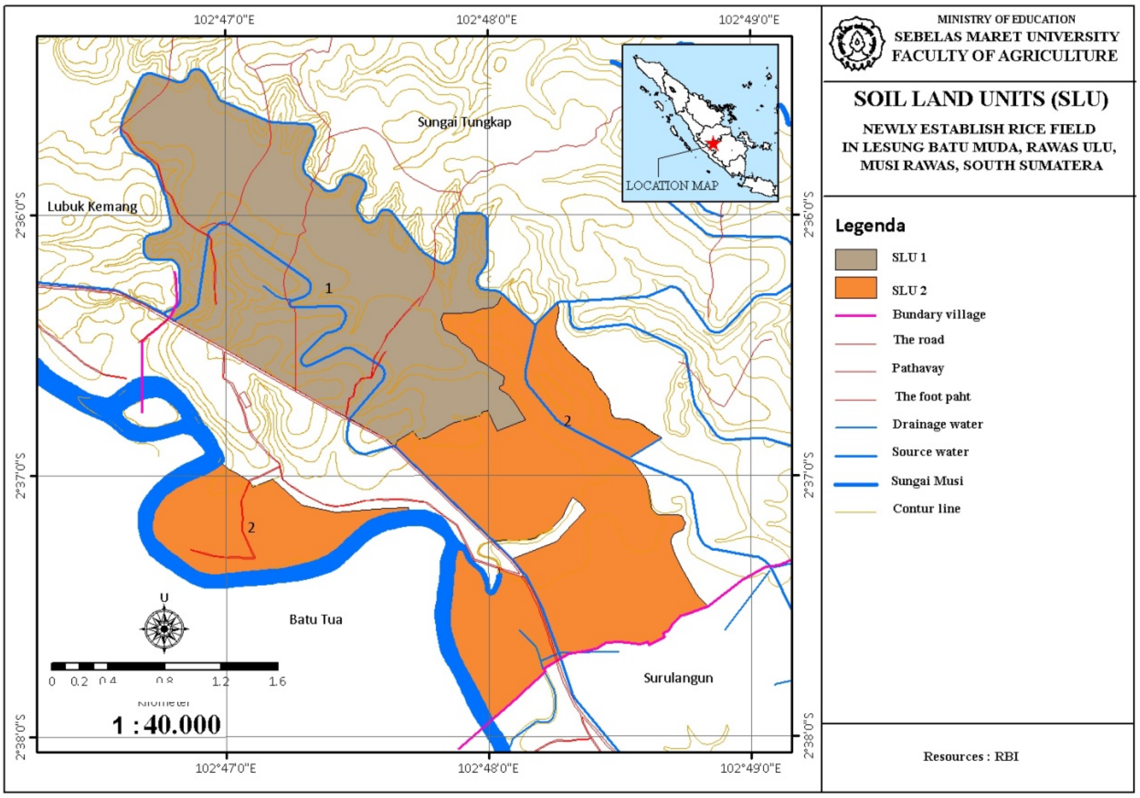

Figure 2. Land suitability map of newly established rice field in Lesung Batu Muda, Rawas Ulu, Musi Rawas, South Sumatera

Parameters of the new established rice fields in this study consisted of the soil texture, the drainage, solum, rough materials, erosion, tillage and soil chemical properties. Parameters of soil chemical properties are organic matter, available P, K-available, total-N, and CEC. The soil texture is the ratio between the sand, silt and clay contained in the soil. Lesung Batu Muda had the texture of S1 land capability class (highly suitable) for paddy and had solum between 25 and 40 cm. The solum effectiveness of the land for paddy is more than 50 cm, so the location for the research was not suitable for paddy.

The drainage is the collection and disposal of water from the soil; the drainage is determined by looking at the symptoms i.e. pale, gray or rusty blotches. The pale colour or bluish gray showed a strong influence of stagnant water, so it showed that the air could still get into the soil resulting oxidation, drainage in the research location has S1 land suitability class on the second SLU, with sufficient drainage which is inhibited.

Rough material happens due to the weathering of materials in the form of sand, silt, rock or lava flows. SLU 2 had land suitability with incompatible (S3) rough material reached more than 35%. While SLU 1 had unsuitable land suitability containing roughly 15 to 35%. The presence of rocks in the soil surface may disturb the plant roots and reduce the ability of the soil in a variety of land use. From the observation of the surface rock at both SLU, it had S1 land suitability class's type (highly suitable).

Land slope is one of the most important factors in the assessment of newly established rice fields. Slopes in Lesung Batu Muda showed the land suitability matched with the type S1 category at SLU 1 with 7.7% percentage, while the type S3 are quite suitable to SLU 2 with the percentage of 2.6%. According to Hanafiah (2007), if the land will be used for rice cultivation in the steep slope, the terraces must be made to reduce erosion. The observation of the surface rocks of both time points SLU as highly suitable.

Rice planted on terraced paddy fields offers the greatest level of soil conservation. The estimated annual soil erosion rates of the Sui-li Creek watershed in Central Taiwan are 29.5 t/ha by using the Agricultural Nonpoint Source Pollution Method (AGNPS). The application of USLE in the estimation of the annual soil erosion rates for the Shi-Men (40 t/ha) and Fai-Tsui (34 t/ha/yr) watersheds in Northern Taiwan. Although these watershed areas are strictly protected from any land development, their annual soil erosion rates were still notably greater than the terraced rice fields (Chen et al., 2012). Land suitability of Lesung Batu Muda which was classified as S3 was marginally suitable. This case showed that both of SLU were observed having the organic matter content of less than 2.5%. This happened because the soil in the village of Lesung Batu Muda is classified as a yellow-red podsolic. The organic matter content of the test soils was higher than the control. Apart from the topsoil samples (0-10cm), others were within the same range in the two sites. The organic matter reflects soil carbon, nutrient availability and substrate for most soil biological activity (Bunning and Jimenez 2003). The soil organic matter is integrally tied to many soil quality indicators and is arguably the most significant single indicator of soil quality and productivity (Larson and Pierce 1991; National Research Council 1993; Cannel and Hawes 1994; Robinson et al., 1994).

The soil organic matter serves as the energy source for microbial processes, respiration and nutrient storage and turnover. The soil quality minimum data set of indicators is vitally dependent on soil organic matter (SOM). Other soil quality indicators that are inextricably linked to SOM are plant's available water capacity (Hudson, 1994), and infiltration (MacRae and Mehuys, 1985; Boyle et al., 1989; Pikul and Zuzel, 1994), aggregate formation and stability (Tisdall and Oades 1982; Oades, 1984; Burns and Davies 1986).

Potassium is one of the major nutrients that is essential for plant growth and development. Although the concentration of K^+ in the soil solution $(K+\rfloor_o)$ is in the range of only 0.1-6 mM (Adams, 1971), plants accumulate large quantities of this element, which constitutes between 2% and 10% of plant's dry weight (Leigh and Jones 1984; Tisdale et al., 1993). The phosphorus in the areas of Lesung Batu Muda had the suitability of the land type of was highly suitable S1 (more than 0.31%). Potassium serves as an activator of enzymes and metabolic processes. Higher values of potassium were found at topsoil samples from the test samples when compared with the control. Potassium concentrations in the soils should ordinarily increase along with soils depth, as in the control. This change, in order could be attributed to the NPK fertilizers, was constantly applied to the farms and constant tillage with heavy machinery. Most of this potassium was not available to plants as they did not dissolve but was trapped between layers of clay minerals. Potassium uptakes by plants are affected by several factors which include soil moisture, soil aeration and oxygen level (Egejuru et al., 2014). Potassium fertilizer was supplied at 161 kg/ha as K_2O with a high dispersion of data. In some exceptional cases, even more than 300 kg/ha of potassium is applied, when KCl was added to a distribution of manure: farmers in Piedmont tend to underestimate the nutrient content of manure (Grignani and Zavattaro, 1999). The fertilizer was spread mainly before sowing (>60% of the total), 18% on the surface; half as basic fertilization and half as top dressing, 21% on the surface and it was spread totally as top dressing of 33% on the surface. The results of the observations showed that the content of K available and P-available at the research area were suitable for paddy because the land suitability type was S1. Plants absorb P from the soil in the form of phosphate ions which is present in the soil solution. H_2PO_4 ion is found in acid soils, whereas $HPO4_2$ ion is found in alkaline soils. In addition to these ions, the plants may absorb P in the form of nucleic acid, fitine, and phosphohumate (Hanafiah, 2007).

Nitrogen is the nutrient which regulates net plant primary production in most ecosystems (Lambers et al., 1998). A mechanical knowledge of the soil N cycle is therefore critical in understanding the behaviour of ecosystems and their responses to natural and anthropogenic mediated change. While the production and fate of inorganic N (NH_4^+ and NO_3^-) are well understood (Jarvis et al., 1996; Murphy et al., 2003), our comprehension of the processes prior to the production of NH_4^+ within the N cycle remains poor. Dissolved organic nitrogen (DON) may play a key role in determining vegetation succession particularly in pristine ecosystems (Chapin et al., 1993; Raab et al., 1996). Nitrogen in the areas of Lesung Batu Muda is extremely low and the suitability of the land type is marginally suitable S3 (0.05-0.1). The source of acquisition of soil Nitrogen is derived from the soil organic matter by mineralized NH_4^+ and NO_3^- (Sanchez et al., 1982).

The growth of rice and aquatic weeds was affected by previous crop conditions. The decrease of NH_4^+-N and MinNacf during crop cultivation accounted for 18-35% of ^{16}N taken up by the plant. The ^{16}N abundance of MinNacf (mineralized N of chloroform-fumigated soil during anaerobic incubation) was almost constant during the second cropping season. The amount of MinNacf and N taken up by rice under N-deficient conditions in the two cropping was highly correlated (r=0.885*), supporting the hypothesis that MinNacf is a major source of N for rice under these conditions (Inobushi and Watanabe, 1986). Low N fertilization limited N uptake during vegetative growth, which constrained any increase in spikelet number, thereby limiting the yield response (Kim et al., 2003). Low N may also cause more pronounced acclimation of the photosynthesis which elevated CO_2 that can limit total dry matter and leaf area increases at elevated CO_2 (Suter et al., 2001; Ainsworth et al., 2003).

Both geochemical and biological processes regulate the availability of phosphorus in soils. At the global scale and over the long term, geochemical processes link the movement and distribution of phosphorus between two large pools-terrestrial soils and ocean sediments (Richey 1983; Schlesinger 1991; Ramirez and Rose 1992). Phosphorus in the areas of Lesung Batu Muda with the suitability of the land type is highly suitable S1 (more than 15%). The soils that dominate humid temperature and tropical regions (Ultisols and Oxisols) are highly weathered, acidic, and dominated by large quantities of sesquioxides. These soils easily absorb and geochemically fix phosphorus, in many cases leading to phosphorus limitations (Johnson and Cole1980; Sanchez et al., 1982; Sollins et al., 1988).

Fertilizer P rates at the field level can then be further adjusted based on the use of organic materials, which, when relatively rich in P, can contribute to P balances. Uncertainty exists regarding P supply from organic materials because the organic materials can vary greatly not only in P concentration but also in the rate of release of plant-available P. The supply of P from organic materials, at least in the short term, is probably less than the supply from manufactured chemical fertilizer, in which case, one unit of P from organic materials will substitute for less than a comparable unit of P from manufactured chemical fertilizer. The effectiveness in replacing P from manufactured chemical fertilizer might increase, however, through longer-term application of organic materials. Appropriate adjustment in fertilizer P rates for P supplied by added organic materials is consequently a challenge (Buresh et al., 2010).

Application of organic matter will increase methane production through its influence on the decrease of Eh and provide a source of C. However, the rate and methane production rate depends on the quantity and quality of organic materials applied (C/N ratio, cellulose content, degree of humification and others). Application of rice straw (high C/N ratio) significantly increases methane production. The addition of compost (humified, low C/N ratio) does not give any effect to the production of methane (Nieder and Benbi 2008).

The cation exchange capacity (CEC) is chemical property that is closely related to soil fertility. The soil of Lesung Batu Muda village had clay CEC of 16 cmol. Observations showed that the research areas were suitable for new openings of wetland. The soil with a high CEC is able to absorb and provide nutrients better than the soil with low CEC. If nutrients are in the sorption complex colloid, the nutrients are not easily leached. Rate of 20-25 t organic fertilizer/ha was the best organic fertilizer rates for restoring soil fertility. If it was correlated with total-K-total, total-P, and CEC of the soil, the superior stated treatment also contributed to the increase of soil nutrient contents (Table 4). The application of organic fertilizers positively affected soil CEC and total-K but did not relatively affect total-P content, especially at planting design treatment for field rice with 0-15 t organic fertilizers/ha. The stable soil N, P, and K contents until fallow period were only found for the maize-groundnut and dry field rice-groundnut planting design treatment, although the rate of organic fertilizer applied was only 5-10 t/ha (Ernawati et al., 2014).

Conclusion

Lesung Batu Muda, Rawas Ulu, Musi Rawas, can be used as a newly established rice field by planting twice a year. The newly established rice field in the land productivity can be enhanced through the addition of organic fertilizers, integrated land management and creation of terraces on sloping land. Further research needs to be done with additions of complex variable observations. The addition of sample points needs to be done, so that the data obtained can be more accurate.

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