The Impact of Newly Split Rice Fields in Muara Kelantan Sungai Mandau Village, Siak Regency on Iron (Fe) Content

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Abstract. Soils with a red soil color indicate high soil Fe content (for example Ultisol soil), which if flooded or paddy fielded, the Fe^{3+} in the soil which is *immobile* will be reduced to Fe^{2+} which is *mobile* . Fe^{2+} in certain concentrations is toxic to plants. Consequently, iron (Fe) poisoning emerges as a significant challenge in newly established rice fields. The initial soil analysis conducted for this study was performed at the Central Plantation Services laboratory. This meticulous analysis is crucial in identifying and addressing the specific challenges that Fe poisoning presents to the viability and productivity of these agricultural lands.. Soil samples were taken in Muara Kelantan Village, Sungai Mandau district, Siak Regency with a depth of 0-25 cm from the ground surface. With the time that the rice fields have been used for 5 years. The initial soil analysis results showed a soil Fe content of 4881ppm.

Keywords: Iron, Rice Fields

1 Introduction

The need for rice increases along with population growth , For this reason, rice availability must always be maintained, sustainable and increased. Some _ business that need to be implemented simultaneously include controlling agricultural land conversion, print land agriculture new And intensification system agriculture by implementing technology that can increase productivity and at the same time maintain environmental quality . To meet rice needs Riau Province still depends on its food needs from surrounding provinces such as West Sumatra and North Sumatra.

For this reason, the Riau Provincial Government has made agricultural development policies, especially rice crops, through the OPRM (Riau Makmur Food Operation) program. To support the OPRM program through extensification efforts, namely expanding agricultural areas, Riau is preparing 30,000 ha of land for the construction (food estate). Regency producer rice in Province Riau Wrong the only one is Siak Regency and Sungai Mandau sub-district are the third largest rice producing sub-districts in Siak Regency after Bunga Raya District and Sabak Auh District .

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Riau Province's development priorities in supporting OPRM activities in the field of land resources, apart from extensification, need to be carried out continuously among them control conversion land agriculture, creating new agricultural land and intensifying agricultural systems by applying technology that can increase rice crop productivity. However, efforts to become self-sufficient in rice are faced with various obstacles, including the type of soil that dominates in the Riau area. According to research results [1] The dominant soil in Sumatra is Ultisol and Inceptisol which occupy around 47% of the total area, and Riau Province is the largest area with an Ultisol soil distribution of 2,191,601 ha followed by North Sumatra around 1,524,414.

Ultisol according to Soil Taxonomy has an argillic horizon and base saturation <35%, brownish yellow to red, in Dudal Supraptohardjo's classification (1961) classified as Podzolic Red Yellow (PMK), pH flat <4.50, saturation Al tall, poor hara macro And material organic [2]

The problem that often arises in using Ultisol soil for paddy fields is that soils with a red soil color indicate high soil Fe content, which if flooded or paddy fields then Fe 3+ in the soil which is immobile will be reduced to Fe 2+ which is mobile . Fe 2+ in certain concentrations is toxic to plants. Therefore, Fe poisoning is a major obstacle in in newly established rice fields. Although need paddy will iron more tall from plant other but iron content exceed > 300 ppm nature toxic And can give rise to influence secondary, namely reducing the absorption of other nutrients including the element phosphate which is element important for plant [3]. Land ricefield for rice plants, iron is not considered a microelement. Rice plants assimilate iron in large quantities, but despite the rice's need for it iron more tall from on plant other, but rate iron plant Which High levels can poison plants. Symptoms of Fe toxicity in rice occur in flooded conditions. Reducing conditions cause the dissolution of Fe into a soluble form (Fe 2+). In the context of rice cultivation, the detrimental effects of excess iron in the soil solution are a matter of significant concern. A direct correlation has been observed where higher concentrations of Fe in the soil solution escalate the severity of iron toxicity symptoms in rice plants. This increase in soil Fe concentration is directly linked to inhibited growth in rice. Specifically, it has been documented that an Fe concentration in the soil solution of 200 ppm or more adversely affects the growth of both Margasari and IR 64 rice varieties, leading to stunted growth patterns [4]. Moreover, it is noteworthy that the Fe concentration tends to rise dramatically after 3-4 weeks of flooding, reaching levels as high as 600 ppm [5]. This information underscores the critical need for careful monitoring and management of Fe levels in rice-growing environments to prevent adverse effects on crop health and yield.

Reflecting on the issues outlined previously, it becomes imperative to conduct detailed soil Fe analysis in the newly established rice fields. This research is particularly crucial for fields in Muara Kelantan Village, located in the Sungai Mandau District of Siak Guna Regency. The primary objective of this analysis is to identify and develop effective management strategies. These strategies are essential to support the growth and yield of lowland rice in these newly opened fields. By implementing the right management concepts, we aim to significantly enhance soil productivity, thereby realizing the full potential of lowland rice production in these areas.

2 Research Methods

Research is carried out in laboratories. Soil analysis was carried out at the Cetral Plantation Services. Soil samples were taken in newly opened rice fields (opened 5 years) in Muara Kelantan Village, Sungai Mandau District, Siak Regency at a depth of 0-25 centimeter from the ground surface. The soil analysis carried out is as follows:

Table 1. Types of Initial Soil Analysis on the Chemical Properties of New Opened Rice Fields in Muara Kelantan Village, Sungai Mandau District, Siak Regency

No	Type Analysis	Method	Unit
1.	pH H_2O	-	-
2.	C-Organic	Gravimetry	%
3.	N-total	Kjeldahl	%
4.	C/N		
5.	P-available (P_2O_5)	Bray-2	mg P_2O_5/100g
6.	Basics can exchanged		
	a. Ca-dd	AAS	cmol(+)/kg
	b. Mg-dd	AAS	cmol(+)/kg
	c. K-dd	Flamephotometry	cmol(+)/kg
	d. Na-dd	AAS	cmol(+)/kg
7.	CEC	NH_4OA_c pH 7	cmol(+)/kg
8.	Al-dd	Titrymetry	cmol(+)/kg
9.	Saturation Al	-	%
10.	H-dd	Titrymetry	cmol(+)/kg
11.	Base Saturation	-	%
12.	Micro Elements available		
	Fe -dd	AAS	ppm

The analysis of soil characteristics were analyzed using the criteria proposed by the Bogor Soil Research Center 1983.

3. Results And Discussion

The analysis result of the chemical properties of the soil of the newly opened rice fields in Muara Kelantan Village taken at a depth of 0-25 cm are presented in table 2 below:

This study presents the findings from a comprehensive analysis focusing on the chemical properties of the soil in the newly established rice fields of Muara Kelantan Village. The data, extracted from soil samples collected at varying depths up to 25 cm, are meticulously compiled in Table 2, as shown below. This analysis is pivotal in understanding the soil's fertility and suitability for rice cultivation, offering valuable insights for agricultural planning and sustainable crop management in the region.

Table 2. Results of Initial Soil Analysis of the Chemical Properties of New Opened Rice Fields in Muara Kelantan Village, Sungai Mandau District, Siak Regency

No	Type Analysis	Mark	Criteria
1	pH H_2O	4.70	Sour
2	C-Organic (%)	14.3	Very high
3	N-total (%)	0.43	Currently
4	C/N	33.3	Very high
5	P-available (ppm)	107.4	Very high
6	Basics can exchanged		
	a. Ca-dd (cmol(+)/kg)	8.18	Currently
	b.Mg-dd (cmol(+)/kg)	4.37	Tall
	cK-dd (cmol(+)/kg)	0.89	Tall
	d.Na-dd (cmol(+)/kg)	0.13	Low
7	CEC (cmol(+)/kg)	32.2	Tall
8	Al-dd (cmol(+)/kg)	7.17	
9	Al saturation (%)	22.27	Low
10	H-dd cmol(+)/kg	2.78	
11	Saturation (%)	42.1	Tall
12	Micro Elements available		
	Fe -dd (ppm)	4881	Very high

The data presented in Table 2 above clearly indicate that the soil in Muara Kelantan Village possesses a robust nutrient profile, conducive to plant growth and production. A key feature of this soil is its remarkably high organic matter content, which significantly contributes to an elevated Cation Exchange Capacity (CEC). Additionally, the soil boasts high levels of macro nutrients, including Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), and Magnesium (Mg). This rich nutrient availability is likely attributable to the fertilizers applied during land management, despite previous unsuccessful attempts at using this land for rice cultivation. Furthermore, the soil analysis reveals an exceptionally high level of available Fe-dd, recorded at 4881 ppm. Such a concentration suggests a potential risk of iron toxicity in the soil. Soil pH plays a crucial role in iron availability. According to existing research, an increase in soil pH by one unit above the neutral level can lead to a 95% reduction in iron availability [6]. The formation of Fe(OH)3 is observed with an increase in OH ion concentration [7]. However, in environments where the pH is below 5, iron availability can surge to levels as high as 2000 ppm [6].

Iron (Fe) is an essential micro nutrient for plants. Iron is absorbed by plants in the form of Ferric (Fe^{3+}) and Ferrous (Fe^{2+}) ions. In acid soil, the form of Fe^{3+} dissolves more easily in the form of Fe^{2+} so that in acid soil the form of Fe^{3+} dissolves more easily in the form of Fe^{2+} . The lowland rice cultivation system which requires flooded (anaerobic) conditions causes a number of soil minerals to be reduced by anaerobic microbes, including Fe^{3+} oxide which was initially unavailable to Fe^{2+} which is more soluble and available to plants. Rice plants require Fe 60-300 ppm [6] ; 250-500 ppm [7] ; and Fe deficiency at Fe levels of 10-30 ppm, while Fe toxicity at Fe concentrations of 1000-2000 ppm [8] ; > 300 ppm [3] ; 400-1000 ppm [6].

Iron (Fe) a role in the formation of chlorophyll, photosynthesis, respiration, nitrogen fixation, DNA synthesis and is a cofactor for a number of important enzymes [9; 10 ; 11 ; 12] .

Fe poisoning can occur in rice plants because excessive Fe $^{2+}$ can disrupt the metabolic process and cause damage to the plant with rusty leaves (*bronzing symptoms*), brown color and an underdeveloped root system. Symptoms *of bronzing* on plant leaves can be seen by the presence of small spots that continue to spread from the tip of the leaf to the base of the leaf. Symptoms of Fe deficiency can be seen starting in young leaves because Fe is not *mobile* in the plant. Chlorosis between the veins of young leaves spreads throughout the leaf until the tips of the leaves turn yellow and dry as shown in Figure 1.

Figure 1. Condition of Paddy Rice Plants in Muara Kelantan Village which are Poisoned by Fe

The newly opened rice fields in Muara Kelantan Village, located in the Sungai Mandau District of Siak Regency, exhibit an exceptionally high content of Fe (iron). This high iron concentration is the primary cause of the failure in rice harvests, as illustrated in Figure 1., for this reason it is necessary to handle appropriate management concepts. Cases of Fe poisoning begin with flooding for several days or more which reduces Fe $^{3+}$ to Fe $^{2+}$ which at high concentrations is toxic to plants. Water management can be an alternative by means of intermittent irrigation *during* the season. planting waterlogged rice plants is not carried out continuously, fertilizing and providing soil amendments and using iron-resistant varieties to increase rice production.

4 Conclusion

The initial soil analysis results of newly opened rice fields in Muara Kelantan Village, Sungai Mandau District, Siak Regency were with a soil Fe content of 4881ppm. It is necessary to handle appropriate management concepts, including water management, fertilization and provision of soil amendments as well as the use of iron-resistant varieties to increase rice production.

References

1. Mulyani A, Rachman A, Dairah A. Distribution of sour land, its potential and availability for agricultural development. In: Proceedings of the National Symposium on the Utilization of Acid Soils, Soil and Agroclimate Research and Development Center, Bogor. 2010. p. 1–23.

2. Prasetyo TB, Ruhaimah, Wardhana SA. Effect of water management on iron (Fe) concentrations in new open rice fields. Solum J. 2006;III(1):8–18.

3. Masganti, Susilawati A, Khairullah I. Control of Iron Poisoning to Increase Rice Productivity in New Opening Tidal Swamp Land. Banjarbaru Swamp Land Agricultural Research Institute [Internet]. 2020;103–13. Available from: http://dx.doi.org/10.21082/jsdl.v13n2.2019.103-113

4. Noor A, Lubis I, Ghulamahdi M, Chozin MA. The Effect of Iron Concentration in Nutrient Solution on Iron Toxicity Symptoms and Growth of Rice Plants. The Effect of Iron Concentration in Nutrient Solution on Iron Toxicity Symptoms and Growth of Rice. JAgronIndonesia 40 [Internet]. 2012;40(2):91–8. Available from: https://doi.org/10.24831/jai.v40i2.14311

5. Saidi BB, Hendri J, Suratman. Assessment of water management technology on rice productivity on iron poisoning rice fields in Jambi. E3S Web Conf [Internet]. 2021;306:04018. Available from: https://doi.org/10.1051/e3sconf/202130604018

6. Mahender A, Swamy BPM, Anandan A, Ali J. Tolerance of Iron-Deficient and-Toxic Soil Conditions in Rice. MDPI [Internet]. 2019;8(31):1–34. Available from: http://www.mdpi.com/journal/plants

7. Joseph B, Gladis R, Aparna B, JS B. Amelioration of Acidity and Iron Toxicity in Lateritic Lowland Rice Soil using Non-Conventional Sources of Calcium. Int J Chem Stud [Internet]. 2020;8(4):2041–4. Available from: http://www.chemijournal.com/

8. Asch F, Becker M, Kpongor DS. A Quick and Efficient Screen for Resistance to Iron Toxicity in Lowland Rice. J Plant Nutr Soil Sci [Internet]. 2005;168(6):764–73. Available from: www.plant-soil.com%0A

9. Nugraha Y, Rumanti A. Breeding for Rice Variety Tolerant to Iron Toxicity. Food Growing Science and Technology [Internet]. 2017;12(1, June):9–24. Available from: https://www.researchgate.net/publication/319273723

10. Maisch M, Lueder U, Kappler A, Schmidt C. From plant to Paddy—How Rice Root Iron Plaque can Affect the Paddy Field Iron Cycling. Soil Syst [Internet]. 2020;4(2):1–19. Available from: http://www.mdpi.com/journal/soilsystems

11. Mowidu I, Tinggogoy DDD. Management of Fe Poisoning in Rice Fields by Farmers in Poso Regency. J AgroPet. 2014;14(2017):19–29.

12. Becker M, Asch F. Iron Toxicity in Rice — Conditions and Management Concepts. J Plant Nutr Soil Sc. 2015;168:558–73.