DISTRIBUTION PATTERNS OF IRON (Fe) IN SOME RICE TOLERANT AND SENSITIVE VARIETIES

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ABSTRACT

The increase in rice production in the future, will be a lot of face increasingly complex challenges, among others, is the lack of rice varieties tolerant to environmental stress, especially to stress the iron (Fe), There are many methods that are often used by researchers to determine the level of tolerance of a variety of plants against various stresses. The purpose of this study is to obtain the distribution pattern of Fe in some lowland rice varieties tolerant and sensitive in paddy fields gripped Fe. Experiments were carried out from February to May 2017 in Koto Baru, Sitiung I, District of Dharmasraya, West Sumatra. Single factor experiment using a completely randomize design, with five replications. The single factor is rice varieties, namely Mekongga, Inpari 24, Inpari 27 and 28. The distribution pattern of iron in rice varieties tolerant and sensitive to occur through the mechanism of uptake and translocation of Fe in vegetative and generative phase gets roots, stems, leaves, grain, and rice. Differences in the levels of Fe in each of the section, showing the ability of each of these varieties to adapt to stress Fe. The rice varieties based on the distribution pattern of Fe can be categorized as tolerant varieties (Mekongga), moderate (Inpari 24 and 27) and sensitive Inpari 28. To obtain grains are rich in iron and is able to grow and produce well preferably on aquaculture using a variety Mekongga with the absorption of iron levels in grains more than 40 mg kg^{-1}.

Keywords: iron, paddy, rice

INTRODUCTION

In Indonesia, rice is an important food crop key should be available in the market. Crop failures and limitations of rice products in the market will be able to affect the stability of the security, political turmoil, social and cultural, and economic. Therefore, an increase in productivity of rice continue to be pursued, in order to improve the incomes and welfare and to improve national food security (Alimoeso, 2014; Utama, 2015).

The increase in rice production in the future, will be a lot of face increasingly complex challenges. Competition and land conversion for agriculture with various other development purposes such as transport infrastructure, office buildings, dams, housing and exacerbated by weather and environmental conditions associated with stress nutrients, climate, weeds, pests and diseases. Another problem, which is no less important is the lack of rice varieties tolerant to environmental stress, particularly stress of iron (Fe) (Sahrawat, 2004; Utama *et al.*, 2013).

There are many methods that are often used by researchers to determine the level of tolerance of a variety of plants against various stresses. Several methods are commonly used, among others, are: 1) Seeing the plants ability symbiosis with soil microorganisms (Utama & Yahya, 2003; Puspitawati *et al.*, 2013), 2) Seeing the growth of plant roots (Ma *et al.*, 2000; Noor *et al.*, 2012), and 3) Seeing the detoxification mechanism by organic acids, either with accumulation or exudation (Haryoko *et al.*, 2012; Gao *et al.*, 2016).

One method to overcome the problems in these marginal lands is to utilize the plant tolerant to environmental stress (Palupi *et al.*, 2013; Utama *et al.*, 2010). Efforts to improve plant growth and neutralize the bad influence of iron becomes increasingly important for improving the growth of plants, especially paddy rice cultivation on new openings. Plants tolerant to environmental stress have the ability to adapt morphology and physiology (Slamet *et al.*, 2015; Utama *et al.*, 2016).

The availability of fertile land for agriculture has been very limited, consequently, like it or not ahead to meet the food needs of the available land is marginal lands in question. To be able to use the land necessary, selection and engineering crop varieties that are tolerant and able to adapt well on marginal land (Anonymous, 2014).

Results of research on mineral soils often encountered poisoning sour Al and Fe, the damage plant roots and low nutrient availability. Efforts to improve the functioning of the root and neutralizes the bad influence of Al and Fe are becoming increasingly important for the growth of plants, especially plants that are planted in the area of acid soils. Attempts to overcome these obstacles is the use of species that are tolerant of nutrient stress (Bashir *et al.*, 2010).

Research on the mechanism of the distribution pattern of the iron in rice varieties tolerant and sensitive, is still very inadequate so from this study are expected to be generated important information about the distribution pattern of the iron in tolerant and susceptible varieties. Information on the distribution pattern of Fe tolerant and sensitive rice plants are very useful for a quick test to determine a relatively tolerant or sensitive varieties and the information is also very useful in engineering tolerant rice varieties, especially Fe stress tolerance.

MATERIALS AND METHODS

Experiment was conducted from April to October 2017 is housed in a new field area openings gripped Fe, at Block E Jorong IV Koto Baru Sitiung I, District of Dharmasraya. Single factor experiment using a completely randomized design, with five replications. The single factor was varieties of rice, which consists of four varieties, namely: 1. Rice varieties tolerant Fe, comprising: $\mathbf{P_1}$ = Mekongga, and $\mathbf{P_2}$ = Inpari 29 and susceptible varieties, comprising: $\mathbf{P_3}$ = Inpari 27, and $\mathbf{P_4}$ = Inpari 28.

Seven days before the plowed land, first performed the irrigation with water for seven days. After that, add cow manure as much as ten Mg ha^{-1} as a source of organic matter, and soil processing performed again by hijacked. Then the rice fields back incubated for two weeks, after it is reprocessed and followed by harrowing till the land ready for planting, and manufacture of experimental plots with a size of 3.5 × 1.5 m.

Rice seeds, soaked in a solution Decis, with a concentration of three g per liter and one ml per liter for 20 minutes, then rinsed clean and soaked for 24 hours. Germination is done by wrapping the rice seed with wet paper and placed in a pan. Planting is done according to a predetermined treatment. The maintenance practices is the third Urea fertilizer dose, SP-36 and KCl in the early plantings. Further provision of Urea 1/3 dose at age six weeks and 1/3 again will enter the generative phase. Weeding is done at two weeks of age and the age of six weeks after planting. Watering is done by turns, and water flooded when the primordial cultivated flowers. Observations were made on each experimental unit as much as three samples of each unit of the character of physiology, the Fe content in the roots, stems, leaves, panicle, rice and grains.

Rice plants dried and weighed (roots, stems and leaves), and then milled to do an analysis of the Fe content on the sample of roots, stems, and leaves. Samples of plants that will be analyzed are weighed by 0.5 g, then in the destruction with H_2SO_4, $HClO_4$, and HNO_3 concentrated and then heated to extract a clear result. Furthermore, the sample was diluted to 50 ml, then measured levels of Fe contained in the extract by using the tool AAS Farian AA 240 with SNI 6989.4.2009 Laboratory method Kopertis Region X.

RESULTS AND DISCUSSION

Distribution Pattern

After the of wetland flooded will cause oxide process Fe^{3+} is reduced to Fe^{2+} compounds. Ground color changes from brown to gray and Fe^{2+} in large quantities dissolved in the soil. Soluble iron concentrations varied from 0.1 to 600 mg kg^{-1} shortly after watering. In acid sulphate soils, the concentration of Fe^{2+} can reach 5000 mg kg^{-1} few weeks after watering. On acid soils with high levels of organic matter and heavy oxides can produce enough iron concentration to a level of toxic Ultisol, Oksisol, acid sulphate peat soil tidal areas (Sahrawat, 2004; Utama *et al.*, 2017).

The results of laboratory analysis of the iron content of the rice plant at the roots, stems, leaves, grain, and rice on vegetative and generative phase, showed the diversity of each variety and plant parts. Showed their diversity, tolerance of differences in adaptation mechanisms by rice plants to stress Fe (Table 1 & 2).

Table 1. Levels of Fe in the roots, stems and leaves of some varieties of paddy at vegetative stage and generative

Treatment Rice varieties	Fe content (%)					
	Root		Stem		Leaf	
	Vegetative	Generative	Vegetative	Generative	Vegetative	Generative
Mekongga	2.86ab	6.89bc	ab0051	0.042 a	0.027 b	0.054 b
Inpari 24	3:42 a	7:23 b	0:46 ab	0.031 b	0.040 a	0.065 a
Inpari 27	2:51 b	9:59 a	0.054 a	0.033 b	0.032 b	0.059 ab
Inpari 28	2.61 b	6:52 c	0.044 b	0.040 a	0.026 b	0.039 c

Values followed by a different letter on the same variables in each treatment showed significantly different at the level of 5% LSD

In Table 1 shows the levels of iron contained in the roots of the generative phase increased compared with the vegetative phase. In Mekongga varieties, Inpari 24, 27 and 28 iron content increases, respectively 1.41; 1.11; 2.82; and 1.50 times compared to the iron content in the vegetative phase. From these data it is seen that increased levels of iron in Inpari 27 and 28 is greater than the varieties Mekongga and Inpari 24. This suggests that the susceptible varieties, iron levels increase more in the roots, especially on the generative phase. The increase in iron levels, is expected to affect the ability of the level of tolerance of rice varieties to adapt to stress iron.

Iron Content

Content of Fe on the shaft, is inversely proportional to the uptake of Fe content in the roots. In the vegetative phase of Fe content absorbed the shaft higher than the generative phase. In Table 1 shows that, there is a decrease of Fe content on the variety Mekongga, Inpari 24, 27 and 28 respectively of 0.18; 0.33; 0.39; and 0.09 times.

Furthermore, on the parameters of the leaf, after the vegetative phase, Fe content when entering the generative phase increase. In Mekongga varieties increased 100%, Inpari 24 increased by 63%, Inpari 27 increased 84% and Inpari 28 increased by 50% compared with the levels in the vegetative phase. Increased iron concentration was highest in Mekongga varieties and the lowest at Inpari 28.

Of the three parameters are visible, that the tolerant and susceptible varieties, the absorption of iron in all sections (Table 1), but the more tolerant varieties Fe absorbed at the roots, especially when entering the generative phase. In the observed parameters was also evident, that all the rice varieties when it enters the vegetative phase of Fe content is absorbed lower but increased in the roots and leaves. The big difference in uptake patterns of Fe content in the vegetative phase to the generative phase, shows the different mechanisms of tolerance of each of the rice varieties in the face of stress Fe.

The highest Fe content contained on Mekongga rice varieties, i.e 56.40 mg kg^{-1}, whereas the lowest Fe content in Inpari 24 significantly different from other varieties (Table 2). While the highest levels of the parameter Fe rice varieties occur in Mekongga, i.e 44.78 mg kg^{-1}, was significantly different from other varieties, namely, Inpari 24 (29.47 mg kg^{-1}), Inpari 27 (27.60 mg kg^{-1}) and Inpari 28 (23.42 mg kg^{-1}).

Table 2. The distribution pattern of iron in some varieties of grain and rice paddy fields on the generative phase

Treatment rice varieties	Fe content (mg kg^{-1})	
	Grain	Rice
Mekongga	56.40 a	44.78 a
Inpari 24	40.33 b	29.47 b
Inpari 27	51.30 a	27.60 b
Inpari 28	54.56 a	23:42 b

Values followed by a different letter on the same variables in each treatment showed significantly different at the level of 5% LSD

In Table 2, it appears that all rice varieties either sensitive or tolerant, all absorbing Fe for translocated to grain or grains. In Inpari 24 Fe uptake in grain was lower than in other varieties, i.e 40.33 mg kg^{-1}, but higher Fe uptake in grains is equal to 29.47 mg kg^{-1}, significantly different from the Mekongga (44.78

mg kg^{-1}) and not significantly different with Inpari 27 and 28 respectively 27.60 and 23.42 mg kg^{1}. Uptake of the highest Fe content in grain and grains are the varieties Mekongga, i.e respectively by 56.40 mg kg^{-1} and 44.78 mg kg^{-1}.

In all parameters were observed (Table 1 and 2) shows that the mechanism of the varieties of rice varieties tolerant and sensitive to adapt to stress Fe in vegetative phase and generative, lies in its ability to regulate the distribution pattern of Fe absorbed gets roots, stems, leaves, grains and rice on vegetative and generative phase. In all varieties are observed visually that the distribution pattern of Fe will rise from the vegetative phase to the generative phase, especially on the parameters of the roots and leaves, but decreased in the stem parameters. Furthermore, on the parameters of grain and rice varieties tolerant Fe uptake was higher than susceptible varieties, except in Inpari 24.

Mechanisms of plant tolerance to stress, nutrient can occur externally and internally (Yang *et al.*, 2002; Utama *et al.,* 2013). Internal mechanism occurs by way of setting the uptake and translocation of Fe gets parts of plants such as roots, stems, leaves, rice and grains. In plants more tolerant Fe translocated to the roots and grains from the other gets (Bashir *et al.*, 2010).

Adaptation through an external mechanism requires the existence of mechanisms of avoidance *(avoidance)* of the internal water deficit, while the internal mechanism requires a high tolerance to stress networks Fe or avoidance of the high Fe concentration in tissue (Gao *et al.*, 2016). High Fe content as a result of the irrigation of paddy fields causing reduction of Fe^{3+} to Fe^{2+} lead to poisoning. Another problem, which often arises is the low level of soil fertility due to the binding of nutrients by heavy metals (Utama *et al.*, 2012). Wetland poisoned Fe, will lead to impaired growth and development of plants, especially on susceptible varieties.

The main difference from the mechanism of adaptation is in the area where bonding, whether in symplast *(internal)* and apoplast *(external).* Both of these mechanisms may occur simultaneously, although in different degrees according to the type of plant and its ability to adapt (Way *et al.*, 2012).

Results of research on several plant varieties tolerant such as corn, soybeans, wheat, legume cover crop and paddy demonstrate the ability of the roots of the plant to continue to grow and thrive well even in drought stress nutrient (Sunadi *et al.*, 2010; Lestari *et al.*, 2012;). Adaptability of plants to stress, can also occur through nitrate metabolism (NO_3^-), ammonium (NH_4^+), nitrite ($N0_2^-$), phenolic acids, as indicated by differences in the levels of NO_3^-, NH_4^+ and $N0_2^-$ between species are sensitive and tolerant (Utama, 2010).

The variables root dry weight, is an important indicator to look at stress tolerance and adaptability in acid soils. Damage to the hood cells occurs because plant roots Ca deficiency plays an important role in the development of plant cell walls. In tolerance species there is a layer of slime *(mucilage),* which acts to absorb most of Al in the rhizosphere thus protected from damage plant roots. The results showed that, allegedly on rice plants also have in common the mechanism of tolerance to environmental stress conditions, such as Fe^{2+} stress. The mechanism of stress tolerance can occur internally or externally (Bashir *et al.*, 2010).

Attempts to produce varieties tolerant, needs to be supported by the information on the pattern of the spread and distribution of Fe in rice varieties tolerant and sensitive. Such information will assist plant breeders in particular rice, in the selection and breeding of plants tolerant Fe. The result of this research is very important as an information technology development to stress Fe breeding, particularly the varieties grown on marginal land in order to expansion and intensification of rice as a food source.

CONCLUSION

The distribution pattern of iron in rice varieties tolerant and sensitive to occur through the mechanism of uptake and translocation of Fe in vegetative and generative phase gets roots, stems, leaves, grain, and rice. Differences in the levels of Fe in each of the section, showing the ability of each of these varieties to adapt to stress Fe. The rice varieties based on the distribution pattern of Fe can be categorized as tolerant varieties (Mekongga), moderate (Inpari 24 and 27) and sensitive Inpari 28. To obtain grains are rich in iron and is able to grow and produce well preferably on aquaculture using a variety Mekongga with the absorption of iron levels in grains more than 40 mg kg^{-1}.

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