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Bio Fortification Iron for Brown Rice Variety on Paddy Field Gripped Ferrous

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Abstract

The aim of this experiment was to increasing production and iron content of the brown rice, through the bio-fortification program in paddy fields gripped the iron. The experiment was conducted in the Sub-District of Koto Baru, Dharmasraya, from March to July 2015. The purpose of the experiment is to produce, grain brown rice super high levels of iron, and increased production of brown rice. Methods of bio-fortification with iron in biofortification method in the fields of ferro gripped, by utilizing the technology package can increase production paddy cultivation reached 5.1 Mg ha^{-1} with the iron levels of 25.6 mg kg^{-1} Inpari 24.Brown rice tolerant varieties (Inpari 24) + Ameliorant cow manure 10 Mg ha^{-1} + System of square utama [(7.5 × 7.5 cm) × 25 cm × (7.5 × 7.5 cm)] + One seedling per planting point, age 10 day + plant growth regulators, auxin 5ml $liter^{-1}$ can be used to achieve the growth and production of the best for brown rice varieties cultivation on paddy fields gripped Fe, especially in Koto Baru, District of Dharmasraya.

Keywords: bio-fortification, brown rice, paddy field and iron

Introduction

Approximately 100 million people in Indonesia, according to the health ministry suffer brown from deficiencies of micronutrients such as iron and iodine. This occurs because not all their ability to buy nutritious food, but all rely on the consumption of nutrient intake from rice alone (Finesso, 2012; Anonymous, 2012). Deficiency of iron (Fe) in children, will lead to various diseases such as; anemia, recurrent infections, lower intelligence, emotional disturbances, and even can cause permanent brain damage (Muhammad and Sianipar, 2005; Andarina and Sumarmi, 2006; Masrizal, 2007).

According to the WHO, nearly 3 billion people are deficient in micronutrients, while inIndonesia about 30-60% of children under five and pregnant women suffer from the deficiency of micronutrients (Anonymous, 2012). The high level of the national rice consumption reached 139.15 kg $capita^{-1}$ $year^{-1}$ (Anonymous, 2014), is an opportunity to improve the micronutrient deficiencies, especially iron.

High levels of dissolved Fe^{2+} in the fields of new openings (Table 1), a potentiel that needs to be exploited, to harvest rice grain with a high iron content by the method of bio-fortification. Methods of bio-fortification iron are how to cultivate the plant, on land that is rich in a solution of iron (Fe), so the plants can naturally absorb many substances dissolved in the root zone, taking advantage of the tolerant plants. Efforts to increase the absorption of iron by the method of bio-fortification, conducted by treatment with growth regulators, because of its ability to manipulate the power of Source-Sink on plants (Salisbury and Ross, 1992; Hopkins, 1995; Zulkarnain, 2009), thus affecting the increasing uptake of iron in rice grain.

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Brown rice has long been used for porridge baby food, even a lot of selling in the form of prepabrown products. Brown rice is also used for the treatment of certain diseases such as diabetes, heart disease, post-menopausal recovery, improving blood circulation, prevent belly fat, and high blood pressure. Besides brown rice is also believed to prevent cancer because it contains anti-cancer substances such as; fiber, selenium, phenolic and lignin. Brown rice contains antioxidants such as phenolic acids, flavonoids, anthocyanins and proanthocyanidins, tocopherols and tocotrienols (vitamin E), γ-orizanol and fitik acid (Anonymous, 2015a; Anonymous, 2015b).

Indonesia is number three rice-producing countries in the world, but because of the level of consumption is still very high and very large number of people, causing Indonesia continued to import of the rice to meet domestic demand. Efforts to increase production pursued with various efforts, in order to increase incomes and welfare and to improve national food security (Alimoeso, 2014).The low productivity of land due to limited technology and the cultivation of the rice varieties tolerant to environmental stress, a problem that is often found in cultivation in paddy fields gripped the iron. Engineering cultivation technology, for increased production and iron content of the brown rice, through the bio-fortification program in paddy fields gripped the iron, need to be examined more deeply.

Materials And Method

The experiment was conducted from March to July 2015, the new openings wetland located in Block E Jorong IV Situng I, Koto Baru, District of Dharmasraya, West Sumatera, Indonesia and Laboratory Kopertis Region X. This experiment used two-factors of a factorial design in a Completely Randomize Design with three replications. The first factor was the brown rice varieties; namely: Inpari 24; Inpara 7 and Inpago 7. The second factor was a plant growth regulator, namely: Auxin 0 ml liter^{-1}(control) andAuxin 5 ml liter^{-1}. The combination package technology used in these experiments, namely:Ameliorant cow manure, 10 Mg ha^{-1} +System of square utama [(7.5x7.5 cm) x 25 cm x (7.5 x 7.5 cm)] so that in one clump there are four seeds (one seedling per planting point) +The young seedling age 10 days (Utama et al., 2013; Utama et al., 2016).

Brown rice seed, prior to germinating soaked in a solution of deltamethrin, a concentration of 3 g liter^{-1} and 1 ml liter^{-1} for 20 minutes, then rinsed thoroughly and soaked for 24 hours. Rice field flooded with water for 7 days, then added ameliorant form of cow manure as much as 10 Mg ha^{-1} as a source of organic material. After that, the soil depth of 25-30 cm and incubated for 2 weeks. Then reprocessed and followed by harrowing till the land ready for planting, after it carried out the establishment of the experimental plots with a size of 6.0 x 3.0 meters.

Germination was done by wrapping the rice seed with wet rice paper in the seedbed, after germination, the seed rice paper opened up to the age of 10 days. Then immediately planting rice seedlings in paddy fields which have been prepared in accordance with the treatment. Planting is done in accordance with a prepared determined technology package, using the SRI method of cultivation activities.Maintenance activities include fertilizing with manure of Mutiara (25:7:7) at the beginning of the planting. A further provision of supplementary fertilizer the second, when she was 6 weeks with the content of NPK (15:17:17) and third again will enter the generative phase. Weeding was done at ages 2 and 6 weeks after planting. Watering was done intermediates, and water inundated cultivated when primordial interest. Harvesting was done after the flag leaf yellowing 80% of the total population and dried grain panicle.

Observations were made on each unit experiment as much as three samples for each unit of some important agronomic and physiologic characters such as the length of panicle, number of panicles clump^{-1}, number of grain panicles^{-1}, weight of 1000 grains, dry grain milled (DGM) plot^{-1} and ha^{-1} and levels of iron in the grains brown rice. Levels of iron (Fe) grains measured by AAS Varian AA 240 with methods of SNI 6989.4.2009 in the Integrated Laboratory Kopertis Region X. All data were statistically analyzed by analysis of variance (ANOVA). Comparisons among means were analyzed by using Tukey test calculated at $P< 0.05$.

Results and Discussion

The ferrous ion levels will increase with the flooding, which caused the reduction of $Fe^{3+}$of being Fe^{2+}. Low soil fertility, also an issue frequently asked on paddy gripped the iron (Sahrawat, 2004; Sunadi et al., 2010). The causes poor growth and development of plants, especially sensitive varieties against at nutrient stress (Noor et al., 2012).

Table1. Physical and chemical characteristics of Ultisols soil in Sitiung I Koto Baru, District of Dharmasraya

SoilCharacteristic	Unit	Value	Criteria
Texture			
Sand	%	17.86	-
Silt	%	50.85	-
Clay	%	31.25	-
Class		Clay	-
Depth	cm	0-20	-
Bulk density		1.08	-
pHH_2O	-	5.07	Sour
Organic Matter	-	2.56	-
Organic-C	%	1.49	Low
Total-N	%	0.11	Low
C/N ratio		12.04	Medium
Available P (Bray 2)	mg kg^{-1}	3.29	very low
Arrangement ofcations			
K^+	mol kg^{-1}	0.05	low
Na	mol kg^{-1}	0.13	low
Mg	mol kg^{-1}	0.20	very low
Ca	mol kg^{-1}	0.08	very low
		$\sum=0.46$	
CEC	mol kg^{-1}	14.93	low
Base saturated	%	3.08	very low
ExchangeableAcidity			
Al^{3+}	mg kg^{-1}	4.78	medium
H^+	mg kg^{-1}	0.87	-
Feavailable (Fe^{2+})	mg kg^{-1}	104.69	High
Airdrywater content	%	20	

Source: Utama et al., (2012)

The high solubility of Fe, which reached 104.69 mg kg^{-1} and the low availability of nutrients for plants (Table 1), affecting the growth and development of all brown rice varieties cultivated in these experiments, it can be seen in all parameters of observation (Table 2, 3 and 4). The presence of interactions between the two treatment factors, namely: rice varieties with plant growth regulator (PGR), all parameters were observed, an indication of the different tolerance of each of the brown rice varieties to stress ferrous.

Treatment of growth regulators, the three brown rice varieties, able to increase the length of panicles, the number of panicles clump^{-1}, the amount of grain panicle^{-1}, DGM plot^{-1}, DGM ha^{-1} and the iron content (Table 2, 3 and 4). Growth regulator substances have the ability to influence the development and differentiation of each part of the plant, so it will affect when a part of the plant will continue to grow and the other part to stop growing (Peng and Yamauchi, 1993; Zulkarnain, 2009).

The panicle length on a variety of Inpago 7, significantly different comparedwith Inpari 24 and Inpara 7. The panicle longest contained in the combination treatment Inpago 7 with PGR treatment, ie 29.87 cm, while the shortest panicle varieties of Inpara 7, which is 24.13 cm. For a number of panicles highest in Inpari 24, ie 22.67 fruit, while the lowest for the number of panicles Inpago 7, namely: 11.67 fruit on controls. Furthermore, for the parameter shows the number of grains, there are no significant differences between the varieties in both the control and treatment of PGR (Table 2).

Table 2. The panicle length, number of panicles clump^{-1} and the number of grain panicle^{-1} as a result of experimental bio-fortification iron in ferrous gripped brown rice varieties.

PGRTreatment	Rice Varieties		
	Inpari 24	Inpara 7	Inpago 7
	Panicle Length (cm)		
Auxin 0 ml liter^{-1} (Control)	24.22b	24.45b	28.52a
Auxin 5 ml liter^{-1}	24.37b	24.13b	29.87a
	Σ Panicles Clump^{-1}(pieces)		
Auxin 0 ml liter^{-1}	18.80ab	17.13ab	11.67b
Auxin 5 ml liter^{-1}	22.67a	19.23ab	13.67b
	Σ Grain Panicle^{-1} (grain)		
Auxin 0 ml liter^{-1}	120.40a	123.13a	153.90a
Auxin 5 ml liter^{-1}	120.67a	126.73a	154.40a

Meanfollowed bydifferent lettersonthe samevariablesineach treatmentshowedsignificantly differentat5% levelby Tukey test

The weight of 1000 grains showed no real difference at all treatment combinations, except the combination treatment Inpago 7 varieties with control. The highest grain weight is 32.91 g in treatment between auxin 5 ml liter^{-1}with Inpari 24 and the lowest is at 17:13 g Inpago 7 with control treatment.There is a noticeable difference in the production DGM plot^{-1} and DGM ha^{-1} between Inpari 24 with Inpara 7 and Inpago 7. The varieties of brown rice Inpari 24, can plant and produce well, otherwise the varieties Inpara 7 and Inpago 7, production very low. DGM production highest in Inpari 24, ie 5.1 Mg ha^{-1}, while on the variety Inpago 7 and Inpara 7, respectively only 1.9 and 0.8 Mg ha^{-1} with PGR treatment (Table 3). Inpari 24 is able to grow and produce well, presumably because these varieties tolerant to stress the ferrous (Utama et al., 2015). On varieties Inpara 7 and Inpago 7 is thought to occur because of the high toxicity of ferrous absorption in grains (Table 4), causing production on both the susceptible varieties to be very low.

Table 3. Weight of 1,000 grains, DGM plot^{-1}and DGM ha^{-1} on bio-fortification iron several varieties of brown rice was seized ferrous.

PGRTreatment	Rice Varieties		
	Inpari 24	Inpara 7	Inpago 7
	1.000 Grain Weight (g)		
Auxin 0 ml liter^{-1} (Control)	28.97a	32.34a	17.13b
Auxin 5 ml liter^{-1}	32.91a	31.80a	25.85ab
	DGMProduction (kg plot^{-1})		
Auxin 0 ml liter^{-1}	8.46a	1.96b	1.39b
Auxin 5 ml liter^{-1}	8.94a	3.29b	1.39b
	DGM Production (Mg ha^{-1})		
Auxin 0 ml liter^{-1}	4.8a	1.1b	0.8b
Auxin 5 ml liter^{-1}	5.1a	1.9b	0.8b

Meanfollowed bydifferent lettersonthe same variables in each treatment showed significantly different at 5% level by Tukey test Ferro high solubility in the soil solution, especially in waterlogged conditions (Table 1) led to high hydrogen sulfide compounds and ferrous sulfide in paddy fields inundated, causing the occurrence of iron toxicity in lowland rice varieties are susceptible.Due to its high solubility, will affect the ability of roots to oxidize, especially in susceptible varieties, causing poisoning.

Moreover, the waterlogged conditions will cause a color change of the soil and increase the solubility of Fe^{2+} in large quantities. The solubility of iron in any kind of soil is very diverse (Becker and Asch, 2005; Fageria et al., 2008), between 0.1-600 mg kg^{-1} shortly after the flooding (Barchia, 2009). To address the high solubility of the ferrous, then the rice cultivation land of acid sulphate with a concentration of Fe^{2+} is high, used methods of cultivation with SRI methods (Utama et al., 2013; Utama et al., 2016), this is done to reduce flooding which can increase the solubility of iron.Use of technology packages on susceptible varieties (Inpara 7 and Inpago 7), are not able to boost production because of suspected poisoning in the brown rice plants. It can be seen from the high levels of iron contained in brown rice grain both varieties, even higher than the rice varieties tolerant, Inpari 24 (Table 4). This is presumably because the levels of ion ferrous high and low soil fertility (Audebert and Sahrawat. 2000; Utama et al., 2012), will lead to poor growth and development of plants, (Ma, 2000; Rengel, 2000), especially on varieties sensitive (Haryoko et al., 2012).

Iron puisotin occurs, if the plant accumulâtes iron in high concentrations, as seen on the brown rice grain varieties Inpara 7 and Inpago 7 (Table 4), especially in susceptible varieties. Ultisol used in this experiment, it can produce the ferrous ion concentration to a level that is very toxic. The high concentration of iron in the soil solution will lead to inhibition of uptakes (Becker and Asch, 2005; Dorlodot et al., 2005), such as phosphorus and potassium. Critical limits the concentration of iron in the soil to plants vary greatly depending on the level of tolerance of these plants (tolerant or susceptible) and soil pH (Sahrawat, 2010; Utama et al., 2016). At pH 3.7-5.5 solubility of iron around 1000-300 mg kg^{-1}, the specific symptoms of iron toxicity generally will appear when the iron content of plants more than 300 mg kg^{-1}.

Table 4 shows, there are no significant differences between the varieties of brown rice to the iron levels in grains, but the PGR treatments showed significant differences between the control and treatment of Auxin. In the treatment of PGR levels of iron in the grain brown rice is an average of 33.0 mg kg^{-1} while the control is only 24.8 mg kg^{-1}. In PGR treatments, can increase the absorption of iron in the brown rice grain by 33% compare with controls. Three levels of iron in brown cultivated rice varieties showed different variations, between 19.8- 34.1 mg kg^{-1}.

Table 4. Levels of iron grains in bio-fortification iron several varieties of brown rice were seized ferrous.

PGRTreatment	Rice Varieties			
	Inpari 24	Inpara 7	Inpago 7	Rata-rata
	Iron Content (mg kg^{-1})			
Auxin 0 ml $liter^{-1}$ (Control)	19.8	23.8	30.8	24.8 b
Auxin 5 ml $liter^{-1}$	31.4	34.1	33.6	33.0a
Average	25.6a	28.9 a	32.2 a	

Meanfollowed bydifferent lettersineach treatmentshowedsignificantly differentat5% levelby Tukey test

Table 4 shows, there are no significant differences between the varieties of brown rice to the iron levels in grains, but the PGR treatments showed significant differences between the control and treatment of auxin. In the treatment of PGR levels of iron in the grain brown rice is an average of 33.0 mg kg^{-1} while the control is only 24.8 mg kg^{-1}. In PGR treatments, can increase the absorption of iron in the brown rice grain by 33% compare with controls. Three levels of iron in brown cultivated rice varieties showed different variations, between 19.8- 34.1 mg kg^{-1}.Levels of iron, grain brown rice on Inpari 24, Inpara 7,and Inpago 7 respectively is 25.6; 28.9 and 32.2 mg kg^{-1}, there is no real difference. PGR treatment in Inpari 24, Inpara 7 and Inpago 7 is able to increase the absorption of iron in the grain brown rice respectively 59%, 43% and 9.1% (Table 4). The strength of Source-Sink on brown rice varieties, can be manipulated with the use of growth regulators are appropriate (Hopkins, 1995), so the use of PGR is able to increase the absorption of iron in the grain brown rice (Utama et al.,2015).

Figure 1 shows the grains andrice of brown rice cultivated on the location of the scenes ferrous wetland. The iron content in the brown rice (25.6 mg kg^{-1}), much higher than the levels of iron contained in the rice on the market, which is only 2-3 mg kg^{-1} as stated Inez in Anonymous (2012).

Figure 1. Rice and cooked rice are rich in iron content (25.6 mg kg^{-1}) results from biofortified brown rice cultivated on land seized ferrous.

High levels of iron in susceptible varieties, suggesting that these plants were poisoned. Potassium-deficient plants are often high levels of iron and showed symptoms of severe poisoning. This shows that the method of bio-fortification of iron can only be applied to rice varieties tolerant to iron stress, such as Inpari 24, but not on susceptible varieties (Inpara 7 and Inpago 7). The ability of plants to adapt to be able to affect the status of plant nutrients that play a role in affecting the rice crop tolerance to stress iron (Utama et al., 2013).The tolerant rice plant, able to grow well even in conditions gripped the iron. Implementation spacing of optimal (4 points crops) could encourage vegetative growth early more intensive, because the seeds are still very young (10 days), so avoid the competition early, also driven by the use of plant growth regulator that is able to increase cell division, cell elongation and morphogenesis with SRI cultivation method.

Conclusions and Suggestions

Methods of bio-fortification iron in several varieties of brown rice paddy fields gripped the iron, by making use of cultivation technology package, can increase the production of DGM reached 5.1 Mg ha-1 with the iron levels in rice grain 25.6 mg kg-1. Information on packages of cultivation technology that consists of a combination of: [Rice varieties of brown tolerant, Inpari 24 + Ameliorant cow manure, 10 Mg ha-1 + System of square utama [(7.5 × 7.5 cm) × 25 cm × (7.5 × 7.5 cm)] + One seedlings planting point, age 10 days + plant growth regulators, auxsin 5 ml liter-1] can be used to obtain the best growth and production on paddy rice cultivation gripped Fe soils, especially in Koto Baru, District of Dharmasraya.

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