Culture Management for Rice Containing Super High Levels Fe with Biofortification Method

M Zulman Harja Utama[1], Sunadi[2], Widodo Haryoko[1] and Alrisman Agoes[1]

1) Department of Agronomy Faculty of Agriculture, Tamansiswa University, West Sumatra. Indonesia;
2) Departement of Agronomy Faculty of Agriculture, APPERTA, West Sumatera, Indonesia Jl. Tamansiswa No. 9 Padang 25136 Telp. (0751) 40020/Fax. (0751) 444170 Hp.081266911105/E-mail: harja65@yahoo.com

ABSTRACT

Health Ministry of Indonesia data, about 100 million Indonesian people have indicated by suffering micronutrient malnutrition, because of they don't have ability on purchasing nutritious food, but only depend on the nutrition of rice. Deficiency of iron in children, will cause anemia, recurrent infections, low intelligence, emotional distress, and even can cause permanent brain damage. In Indonesia about 30-60 %, children under five year old and woman pregnant who suffer from deficiency of micronutrients. National high level rice consumption reach 125 kg capita^{-1} year^{-1}, is an opportunity to reduce micronutrient deficiencies, especially by iron biofortification method, by cultivated of rice plants on the new opening area that are rich in Fe dissolved. The aims research to improve the productivity on the new opening area gripped Fe, with target of production grain weight > 7 Mg ha^{-1} with a method to harvest rice biofortified high iron levels with a target of > 30 mg kg^{-1}. The results of the research show that: 1). The highest production obtained on variety of Mekongga with coconut water treatment, they are reached grain weight 7,42 Mg ha^{-1}; and 2) The level of iron in rice grains, in all varieties of the plant growth regulator treatments showed between 18.8-36.2 mg kg^{-1}.

Key words : biofortification, management, rice, iron

INTRODUCTION

Potential land that can be utilized to increase the production of rice is rice field new openings in Dharmasraya with a land area of over 2,691 ha (Anonymous, 2007) , which is influenced by the solubility of Fe^{2+} and Al^{3+} high (Utama , 2010; Sunadi *et al*., 2010) , spread in 4 districts with varied land area, with the details as follows : (1) Sungai Rumbai 41 ha; (2) Koto Baru 1,196 ha; Sitiung 718 ha; and (4) Pulau Punjung 818 ha. The average land productivity is only 2.2-2.5 Mg ha $^{-1}$, while the current national production has reached more than 4.75 Mg ha^{-1}.

Data from the Ministry of Health, shows approximately 100 million people in Indonesia, suffer from deficiencies of micronutrients (iron and iodine) because of their inability to buy nutritious food, but only relying on all the nutrient intake from consumption of rice (Finesso, 2012; Anonymous, 2012). Deficiency of iron (Fe) in children, will lead to anemia, recurrent infections, low intelligence, emotional disturbances, and even can cause permanent brain damage. According to WHO (2000), nearly 3 billion people deficient in micronutrients, while in - Indonesia around 30-60 %, children under five and pregnant women who suffer from the deficiency of micronutrients (Anonymous, 2012). The high level of the national rice consumption reached 125 kg capita^{-1} year^{-1}, is an opportunity to correct the deficiencies of micronutrients, especially iron by the method of biofortification .

Levels of ion ferrous high occurs as a result of the inundation, which led to the reduction of Fe^{3+} to Fe^{2+}, another problem that often arises is the low fertility of the soil (Sahrawat, 2004; Sunadi *et al*., 2010), which causes the inhibition of plant growth and development, especially on varieties sensitive to nutrient stress (Ma, 2000; Rengel, 2000; Utama *et al*., 2009; Utama, 2010; Noor *et al*., 2012) .

Methods of biofortification is the way of cultivating the land is rich solution of iron (Fe), so the plants can naturally absorb dissolved substances in the root zone, by utilizing tolerant

plants. Increased uptake of iron levels by the plant by the method of biofortification, was done with the treatment plant growth regulator auxin, because of its ability to manipulate the power of Source-Sink on plants, thereby increasing the absorption of iron in grains (Hopkins, 1995; Yang *et al*., 2002).

Market, generally outstanding rice has only the content of iron (Fe) of about 2-3 mg kg^{-1} (Inez *in* Anonymous, 2012). Utama *et al*., (2012) were able to increase the uptake of iron levels between 11.97-21.47 mg kg^{-1}. To increase the production of rice harvest yield and high iron, needed a program to improve the productivity of new openings with wetland rice cultivation technology engineering super high levels of iron (> 30 mg kg^{-1}) by the method of biofortification.

The experiments carried out from February to August 2014, the opening of new paddy fields located in the district of Koto Baru, Dharmasraya and Laboratory Kopertis Region X. Experiments using RAL arranged in a factorial design with three replications. The first factor was the rice variety (V) as follows: V_1 = Inpari 24; V_2 = SBY; V_3 = Inpari 26; V_4 = Inpari 27; V_5 = Inpari 28; V_6 = Inpari 29; V_7 = Inpari 30; V_8 = Ciapus; V_9 = Mekongga; and V_{10} = Anak Daro. The second factor was the growth regulator (Z), namely: Z_0 = 0.0 mg kg^{-1} (Control); Z_1 = 5.0 mg kg^{-1} Auxin; Z_2 = 100% Coconut Water .

Combination package technology used in these experiments, namely: (1). Tolerant varieties Fe and Al; (2). Ameliorant piles of cow 10 Mg ha^{-1}; (3). Spacing square [(10 x 10 cm) x 25 cm x (10x10cm)]; and (4). One seedling per planting hole, age 10 days (Utama *et al*., 2009; Sunadi *et al*., 2010; Utama *et al*., 2012: Haryoko *et al*., 2012).

Before germinating, rice seeds were immersed in the deltametrin solution, with the concentration of 3 g L^{-1} for 20 minutes, after that it was rinsed thoroughly and soaked for 24 hours. Flooded rice field were watered for 7 days, then it was added by a peat soil as much as 20 Mg ha^{-1} as a source of organic material. The amelioran was treated to soil as deep as 25-30 cm. The plot experiments with size 3.0 x 6.0 meters were created. Then, the rice field was incubated for 2 weeks. After it had reprocessed and continued to rake up the land was ready for planting. Germination was done by wrapping with burlap sack of rice seeds.

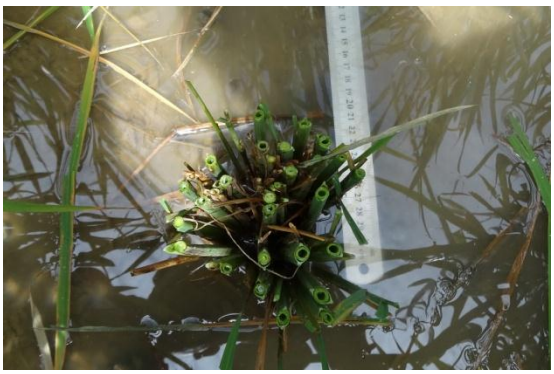
Type of fertilizers given in the early planting were Urea 1/3 dose, SP 36 and KCl. Further provision of Urea 1/3 dose was applicated at age 6 weeks and 1/3 again was applicated at the generative phase. Weeding was done at the age of 2 weeks and 6 weeks after transplanting. Watering was done intermediates, and stagnant water when primordial phose. Harvesting was done after the leaves had turned yellow up to 80% of the total population and grain on the panicles were wither.

RESULTS AND DISCUSSION

The results show, there are variations in the growth and production of all varieties of rice to be treated with synthetic growth regulators (auxin) and natural (coconut water) on all parameters observed. In Table 1 such as the number of grain $panicle^{-1}$, weight of 1000 grain, and grain weight ha^{-1} and levels of iron (Fe) grains (Table 2). The big difference in the growth, showing differences in adaptability of each of these varieties to stress Fe. But all these varieties are able to grow and produce well, it can be seen from the parameter grain weight Mg ha^{-1}, in each treatment (Table 1).

In the conventional cultivation by local farmers, the number of seedlings produced about 20 tillers (Figure 1.A). Treatment of growth regulators can increase the number of tillers 4x more than the conventional cultivation by local farmers. Seedling development very much, in Figure 1.B. Rice plants are able to grow well despite the conditions gripped Fe, because the varieties used tolerant varieties that can adapt to drought stress. In addition, the package of applied technology could encourage the growth of rice plants because of the availability of nutrients .

Application of the spacing of the square (4 points cropping) to encourage the early vegetative growth was better, so the plants avoid early competition (Utama *et al*., 2013) and to encourage vegetative growth was more intensive because the seeds were still very young. The intensive vegetative growth, also driven by the use of PGR that can increase cell division, cell elongation and morphogenesis (Rengel, 2000).



A

B

Figure 1. Seedling growth of the groups with five seeds (farmers) produces 15-20 tillers (**A**), and growth of rice seedlings a clump 4 seed (researcher) with spacing [(10x10cm) x 25cm x (10x10cm)] produces 95-105 tillers (**B**).

Iron levels Inpari 28 (36.2 mg kg^{-1}) were treated with coconut water increased by 62 % compared with controls (22.4 mg kg^{-1}) , while the local varieties Child Daro (18.8 mg kg^{-1}) were treated with water oil decreased by 19 % compared with controls (23.6 mg kg^{-1}). Iron levels in all varieties are cultivated on land seized much higher Fe (Table 1), when compared with the levels of iron grains in the market is only about 2-3 mg kg^{-1} (Inez in Anonymous, 2012). Cultivated varieties (Table 1) was a rice varieties tolerant to stress Fe (Utama *et al*., 2012), so that these varieties can adapt well (Sahrawat, 2014; Noor *et al*., 2012). Moreover, with some cultivation engineering technology packages were also able to increase vegetative growth and generative better.

Table 1. The grains number, 1000 grain weight and grain weight in the biofortification method

TYPES PGR	Rice Variety									
	Inapri 24	SBY	Inpari 26	Inpari 27	Inpari 28	Inpari 29	Inpari 30	Ciapus	Mekongga	Anak Daro
	Grains number									
Control	105.8 gh	101.0 ijk	138.4 ab	137.6 B	99.2 jkl	118.8 d	102.8 hij	95.5 l	141.8 a	109.8 fg
Auksin (5 mg kg^{-1})	104.4 hi	75.5 o	104.7 hi	112.8 ef	105.1 h	115.8 de	85.4 n	85.7 n	97.8 kl	106.0 gh
Coconut Water	101.0 ijk	68.2 p	112.4 ef	126.7 c	97.1 kl	122.9 c	85.4 n	90.3 m	89.0 mn	96.6 l
	1000 Grain Weight (g)									
Control	25.9 j	32.6 c	24.6 l	29.0 f	32.4 c	26.0 j	24.7 l	25.6 jk	39.4 a	24.1 m
Auksin (5 mg kg^{-1})	30.2 e	26.9 i	23.5 n	29.2 f	25.8 j	28.1 g	24.0 m	27.4 h	34.1 b	25.4 k
Coconut Water	25.4 k	23.8 mn	23.9 m	28.4 g	27.1 hi	31.2 d	30.4 e	24.7 l	39.5 a	21.5 o
	Grain Weight (Mg ha^{-1})									
Control	6,77 b	6,88 b	5,91 d	5,42 fg	4,89 h	6,356 c	4,40 ij	3,07 p	5,55 ef	5,61 e
Auksin (5 mg kg^{-1})	5,97 d	4,38 ijk	4,54 i	3,90 m	4,17 l	4,31 jkl	2,02 r	4,44 ij	3,45 n	4,22 kl
Coconut Water	5,26 g	3,88 m	3,89 m	2,75 q	1,92 r	3,95 m	2,85 q	3,41 no	7,42 a	3,27 o

Mean followed by different letters on the same variables in each treatment showed significantly different at 5% level by Tukey test.

Table 2. Iron content in the rice grain growth regulator treatment methods biofortification in SRI

TYPES PGR	Rice Cultivars									
	Inapri 24	SBY	Inpari 26	Inpari 27	Inpari 28	Inpari 29	Inpari 30	Ciapus	Mekongga	Anak Daro
	Iron content (mg kg^{-1}) rice grains									
Control	21.1 hijk	26.8 cdefg	24.1 efghij	20.3 jk	22.4 ghijk	31.1 abc	29.3 bcde	20.5 jk	35.7 a	23.1 ghijk
Auksin (5 mg kg^{-1})	24.0 fghijk	20.3 jk	23.0 ghijk	22.0 ghijk	29.0 bcdef	33.8 ab	23.2 ghijk	21.0 hijk	30.2 bcd	20.6 ijk
Coconut Water	24.2 efghij	26.2 cdefgh	23.8 fghijk	36.0 a	36.2 a	22.1 ghijk	25.2 defghij	20.0 jk	25.8 defghi	18.8 k

Mean followed by different letters on the same variables in each treatment showed significantly different at 5% level by Tukey test.

CONCLUSION

The results showed that the application of packet technology to increase production and iron levels in grains by the method of biofortification, shows the results as follows: 1). The highest paddy production is produced varieties Mekongga with coconut water treatment, namely 7.42 Mg kg^{-1}, and 2). Iron levels in grains, in all varieties of the plant growth regulator treatments show the results between 18.8-36.2 mg kg^{-1}.

Information application technology package (varieties tolerant + ameliorant piles of cow 10 Mg ha^{-1} + spacing of the square [(10 x 10cm) x 25 cm x 10x10cm) + young seedlings (age 10 days) + PGR] with the SRI method can be used to increase production and iron content in rice grain with biofortification method on land seized Fe .

AcknowledgEments

Thanks to DP2M DIKTI, Ministries of Education and Culture for the research funding by Dipa Number: SP DIPA-023.04.2.532476/2014, December 5, 2013, Letter of Agreement, Number: 05/KONTRAK/KM/2014, February 10, 2014, Thanks also to Karno, Sakimin, Noprianto and Ekodri Priyanto for their kind help in this research implementation.

REFERENCES

Anonim. 2007. Kabupaten Dharmasraya dalam angka. Bappeda Dharmasraya dan BPS, Sumbar. (in Indonesian).

Anonim. 2012. Padi berkadar besi tinggi dari kedelai, upaya mengatasi anemia. Kompas, 22 November 2012. Jakarta. Halaman 13. (in Indonesian).

Haryoko, W., Kasli., I. Suliansyah., A. Syarif., T.B. Prasetyo. 2012. Toleransi beberapa varietas padi pada sawah gambut berkorelasi dengan kandungan asam fenolat. J.Agron. Indonesia. 40(2): 112-118. (in Indonesian).

Hopkins, W.G. 1995. Introduction to Plant Physiology. The University of Western Ontario. Jhon Wiley and Sons, INC.

Finesso, G.M. 2012. Mencari padi berzat besi tinggi, memanen matahari. Kompas, 11 Juli 2012. Halaman 14. (in Indonesian).

Ma, J. F. 2000. Role of organic acids in detoxification of aluminum in higher plants. Plant cell physiol. 41(4): 383-390.

Noor, A., I. Lubis, M. Ghulamahdi, M.A. Chozin, K. Anwar, D. Wirnas. 2012. Pengaruh konsentrasi besi dalam larutan hara terhadap gejala keracunan besi dan pertumbuhan tanaman padi. J. Agron. Indonesia. 40 (2): 91-98. (in Indonesian).

Rengel, Z. 2000. Mineral nutrition of crops, fundamental mechanisms and implications. Food production press, Binghamton.

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

Sunadi., I. Wahidi., M.Z.H. Utama. 2010. Penapisan varietas padi toleran cekaman Fe^{2+} pada sawah bukaan baru dari aspek agronomi dan fisiologi. J.Akta Agrosia. 13 (1):16-23. (in Indonesian).

Utama, M.Z.H. 2010. Effect of NaCl-stress on metabolism of NO^{3-}, NH^{4+} and NO^{2-} at several rice varieties. J. Trop Soils. 15 (3):189-194. doi: 10.5400/jts.2010.15.3.189.

Utama, M.Z.H., Sunadi., W Haryoko. 2013. Effect to improve modification of the rice technology package production gripped Fe^{2+}. J Trop Soils. 18 (3): 195-202. doi: 10.5400/jts.2013.18.3.195.

Utama, M.Z.H., W. Haryoko., R. Munir, dan Sunadi. 2009. Penapisan varietas padi toleran salinitas pada lahan rawa di Kabupaten Pesisir Selatan. J. Agron. Indonesia. 37(2):101-106. (in Indonesian).

Utama, M.Z.H., I. Wahidi., Sunadi. 2012. Response of some rice cultivars seized with Fe^{2+} new in aperture fields with multi package technology. J Trop Soils. 17 (3): 239-244. doi: 10.5400/jts.2012.17.3.239.

Yang, J., S. Peng., Z. Zhang., Z. Wang., R.M. Visperas, Q. Zhuand, and L. Liu. 2002. Grain and dry matter yields and partitioning of assimilates in japonica/indica hybrid rice. Crop Sci. 42:766-772.