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Tolerance of F6 Red Rice Lines against Iron (Fe) Stress

Toleransi Galur F6 terhadap Cekaman Besi

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ABSTRAK

Luas lahan kering di Indonesia mencapai 108,8 juta ha (69,4%) dari seluruh total lahan kering dengan potensi perluasan areal tanaman pangan mencapai 7,1 juta ha yang didominasi jenis tanah ultisol dan oxisol. Kendala budidaya tanaman pada jenis tanah ultisol adalah pH tanah yang masam dengan kadar Al dan Fe yang tinggi. Salah satu upaya yang dapat dilakukan untuk budidaya tanaman ditanah ultisol adalah seleksi tanaman yang toleran cekaman Fe. Tujuan penelitian ini untuk menentukan tingkat toleransi galur dan mendapatkan galur padi beras merah F_6 yang toleran terhadap cekaman besi (Fe) di tanah ultisol. Rancangan percobaan yang digunakan adalah Rancangan Acak Lengkap (RAL) faktorial yaitu faktor pertama terdiri dari 12 taraf perlakuan (10 galur uji dan 2 varietas pembanding) dan faktor kedua pemberian cekaman besi dengan konsentrasi (0 ppm dan 551,55 ppm). Pemberian cekaman dilakukan setelah 3 MST. Uji ketahanan cekaman besi (Fe) terhadap seluruh galur padi beras merah F_6 ditanah ultisol mempunyai skor 1 yang menunjukkan toleran cekaman Fe pada konsentrasi Fe 551,55 ppm. Galur 23A-56-30-25-12 dan 23A-56-30-25-13 menjadi galur yang paling toleran cekaman besi (Fe) 551,55 ppm dengan pertumbuhan dan hasil yang paling tinggi. Galur yang diuji dapat dikembangkan di tanah ultisol karena bersifat toleran Fe.

Kata kunci: padi, cekaman, besi, toleransi, seleksi

ABSTRACT

Dryland area in Indonesia reaches 108.8 millions ha (69.4%) of the total dry land with the potential to expand the area of food crops reaching 7.1 million ha, which is dominated by ultisol and oxisol soil types. Plant constraint cultivation on ultisol soil types is the acidic soil pH with high Al and Fe levels. One of the efforts that can be made to cultivate plants on ultisol soil is the selection of plants that are tolerant of Fe stress. This study aimed to determine a tolerance level and F6 red rice lines that were tolerant of iron (Fe) stress in ultisol soils. The experimental design used was factorial Completely Randomized Design (CRD) consisting of 2 factors, the first factor consisted of 12 treatments (10 test lines and 2 comparison varieties) and the second factor was iron stress with concentrations (0 ppm and 551,55 ppm). The stress was applied after 3 WAP. The stress resistance test to iron (Fe) should that all lines of red rice F6 on ultisol soils have a score of 1 which indicates the stress tolerance of Fe at a concentration of 551,55 ppm Fe. The 23A-56-30-25-12 and 23A-

56-30-25-13 lines were the best lines that were tolerant of 551,55 ppm iron (Fe) stress with the highest growth and yield. The lines tested can be developed on ultisol soils because they are tolerant of Fe.

Keywords: iron, rice, selection, stress

INTRODUCTION

Rice is the most important and strategic commodity. The production red rice reach 10% of the rice acreage in china, India, and Vietnam. Infestation of red rice may surpass 10% of total rice area (Morat et al., 2018). National rice production in 2020 reached 54.65 million tons of Dry Milled Grain (DMG) experienced an icrease of 0.08 percent compared to 2019 (SI, 2021). According to Lakitan (2014) Efforts to increase agricultural productivity in suboptimal lands should not jeopardize sustainable function of the ecosystem and participation of local farmers. Sustainability and inclusivity should be maintained while increasing productivity. Efforts can be made to overcome this problem by increasing the productivity of existing rice fields and the development of upland rice cultivation in sub-optimal land. Upland rice can be developed in areas with dry and sedate land conditions (Sadimantara & Muhidin, 2012). More of the areas that is currently trying to increase rice production. The obstacle faced in the cultivation of plant in Bangka Belitung is the state of the soil which is mostly dominated by ultisol soil (Pratama et al., 2014). Ultisol soils have a pH ranging from 3.7 to 6.4. Ultisol soil with a mass pH has a high saturation of Fe and Al. Fe content in ultisol soil reaches 0.27-4.87 g/kg or equivalent to 270-4870 ppm (Darunsontaya et al., 2010). High Fe content will inhibit the growth of rice plant resulting in a decrease in production can even lead to crop failure (Nugraha & Rumanti, 2017).

Rice plant responses to Fe Stress will vary depending on the nature of tolerance and sensitivity to iron poisoning. Excess Fe can damage plant and decrease the absorption of other nutrients such as Ca, P, and K (Kusberyunadi, 2013). Symptoms caused by Fe poisoning are increased height of stunted plants, the number of tillers are low, leaves become ply-brown with leaves that begin to dry up like burning, roots become slight, rough, short, and dark brown (Noor & Khairuddin, 2013). The right technology can use superior varieties that are tolerant to the stress of iron, so that it can cultivate on suboptimal lands. Fe concentration in solution > 200 ppm causing stunted growth of rice plants and concentration 600 ppm causes rice plants to die at 4 MSP Noor 2012. Rice varieties that are tolerant to iron stress 1000 ppm in nutrient culture experiments and podsolik soil media pot experiments are varieties IRH 195, IRH 548, and IRH 715 (Suryadi, 2012).

Gene IRT1 plays in the partitioning mechanism Fe^{2+} to different parts of the plant so that plants can be more tolerant of more Fe^{2+} conditions (Utami & Haranida, 2014). One of the rice plant that is currently being developed is brown rice rice that has been successfully crossed. This red rice seed from crossing between MR1512 x Inpago 8, MR1512 x Banyuasin, Inpago 8 x Balok, Inpago 8 x Banyuasin, Inpago 8 x MR1512, Balok x Banyuasin, Balok x Inpago 8, Banyuasin x Balok, Banyuasin x MR1512, and Banyuasin x Inpago 8. The lines used is F_6 generation from mutant crossing M8-GR150-19-13, Balok, Inpago 8, and Banyuasin. The check varieties used are the Danau Gaung varieties as tolerant varieties and Banyuasin as iron-sensitive varieties. Acording Mulyaningsih et al. (2016) Danau Gaung is a moderate variety of Almunimum, high production and aromatic.

The background above underlies the importance of testing the ability of plants to withstand Fe stress conditions and obtaining superior varieties that are tolerant of Fe stress. The existence of superior varieties cause farmers can cultivate crop power on land containing Fe is quite high. The purpose of this study was to determine the tolerance level of F_6 lines to iron squeaning and obtain F_6 lines of red rice that is tolerant to iron stress.

MATERIALS AND METHODS

The research was conducted from January up to June 2020 in the Experimental Garden of the Faculty of Agriculture, Fisheries and Biology, Universitas Bangka Belitung. The experimental design used was a complete randomized design (CRD) factorial. Factor 1 consists of 12 treatments, namely 10 lines of rice F_6 (19i-06-30-17-17, 19i-06-09-23-3, 21b-57-21-21-1, 21b-57-21-21-25, 19i-06-30-17-27, 23a-56-30-25-1, 19i-06-09-23-27, 23a-56-30-25-13, 23a-56-30-25-12, and 23a-56-24-22-13) and 2 check varieties (Danau Gaung and Banyuasin). Factor 2 consists of 2 treatments, namely without stress (control) and Fe check with a concentration of 551.55 ppm.

Land preparation was carried out by cleaning from weeds and making gauze houses as a place to put research polybags. Planting media used in the form of ultisol soil that has been dried. Dry soil is put into polybags and weighed for each polybag containing 10 kg. Polybags that have contained soil in the gauze house according to the layout that has been made. Grains planted with each planting hole there are 3 grains. The distance between rice-grown polybags was 25 x 25 cm. Treatment of $FeSO_4$ solution in planting media was in accordance with the predetermined field capacity. The iron solution used was made by dissolving $FeSO_4$ as much as 1500 mg in 1 L of water, then watered into polybags. Application of $FeSO_4$ treatment is carried out 21 days after planting. Fertilizer was based on recommended doses of urea as much as 250 kg/ha, SP-36 as much as 150 kg / ha, KCl 125 kg/ha and manure as much as 4 tons/ha. Fertilizer was given at the time of planting and 5 MST for urea fertilizer as much as 1.25 g/polybag. KCl, SP-36, and organic fertilizer fertilizers are given as much as 0.625 g/polybag, 0.75 g/polybag, and 20 g/polybag respectively at the time of planting. Maintenance carried out were watering, fertilizer, weeding, and control of plant destruction organisms. Harvesting was done by observing at the morphological characteristics of rice grains that were characterized by > 80% of the color of the grains has yellowed and when the grain was pressed it feels hard and did not secrete milky white liquid. Selection of Fe-tolerant plants was by observing the visual symptoms of plants in the form of Fe poisoning scoring (Noor et al., 2012). This method could give a fairly clear picture of the differences between Fe tolerant plants and Fe-sensitive plants. This method was expected to be developed for the selection of Fe tolerant plants in large quantities (Nugraha & Rumanti 2017).

The observed characters were plant height (cm), number of leaves (strands), productive tillers numbers, leaves color, root color, flowering time (days), harvest time (days), length of panicle (cm), weight of filled grain (gram), filled grains numbers (grain), root length (cm), root volume (ml) and performing Fe scoring. Fe poisoning score according to *Standard Evaluation System for Rice* (SES) (IRRI, 2013) could be presented in the table below.

RESULT

Soil used as planting media was carried out soil chemical analysis at ICBB (Indonesian Center for Biodiversity and Biotechnology) (Table 1). Parameters of soil chemical properties analyzed were soil pH, total N amount, P_2O_5 available, P_2O_5 potential, K_2O potential, soil KTK, K^+, Na^+, Ca^{2+}, Mg^{2+}, and Iron (Fe) available. The results of soil analysis showed that the soil pH ultisol used as planting media had a pH of 5.06 which was classified as slightly acidic with moderate KTK and low nutrients (Table 2). Fe stress was on 10 lines of red rice (F_6) and 2 comparison varieties (Danau Gaung and Banyuasin) had not different effects on rice plant growth. The results of the analysis of variance on the Fe treatment showed that plant varieties had a significant effect on the plant height, number of leaves, productive tillers numbers, lenght of roots, the volume of roots, the length of panicle, the number of filled grain, the number of empty grains and flowering time. There were differences in harvest time among the varieties or lines. The treatment of Fe 551.55 ppm for F_6 lines and varieties of upland rice showed that was not significant effect on all the character of rice growth and yield. The interaction between the treatment of Fe and plant varieties also exerted that was not significant effect on all observed character (Table 3).

The result of Duncan's Multiple Range Test (DMRT) with a confidence level of 95 % (Table 4), showed that the lines 23A-56-24-22-12 had a good growth compared to other lines based on the observed growth character of plant height, number of leaves, number of tillers, root length, and root volume. The lines with better yields on the character of the number of filled grains, the number of empty grains, the length of panicle, flowering time and harvest time were lines 23A-56-30-25-12 and 23A-56-30-25-13. Lines 23A-56-30-25-12 and 23A-56-30-25-13 have number of grains compared to other lines, but these results were no better than the Danau Gaung as check varieties.

Fe stress treatment of lines and varieties of upland rice was not significant difference to the height of the plant and the number of leaves. Plants that were gripped and not gripped have an average height of almost the same plant. Line 23A-56-30-25-13 even had a higher average number of leaves in the treatment of Fe stress compared to plants without Fe stress (Figure 1a and 1b).

Table 1. Poisoning scale and tolerance level of iron

Scale	Description	Tolerance Level
0	Growth and tillering nearly normal (0 %)	Highly tolerant
1	Growth and tillering nearly normal; reddish-brown spots or orange discoloration on tips of older leaves (1-19 %)	Highly tolerant
3	Growth and tillering nearly normal; older leaves reddish-brown, purple, or orange yellow (20-39 %)	Tolerant
5	Growth and tillering retarded; many leaves discolored (40-59 %)	Moderate tolerant
7	Growth and tillering ceases; most leaves discolored or dead (60-79 %)	Sensitive
9	Almost all plants dead or dying (80-100 %)	Highly sensitive

Table 2. Results of soil chemical analysis before stress treatment

Chemical Properties	Ultisol Land Results	Description
Ph	5.06	Slightly acidic
N Total (%)	0.09	Very low
P_2O_5 Available (mg/kg)	22.51	Very high
P_2O_5 Potential (mg/100g)	12.42	High
K_2O Potential (mg/100g)	6.03	Very low
KTK (cmol(+)/kg	5.06	Moderate
K^+ (cmol(+)/kg	0.08	Very low
Na^+ (cmol(+)/kg	<0.06	Very low
Ca^{2+} (cmol(+)/kg	0.31	Very low
Mg^{2+} (cmol(+)/kg	0.18	Low
Iron (Fe) Available (mg/kg)	41.4	High

Source: ICBB (Indonesian Center for Biodiversity and Biotechnology)

Table 3.The results of analysis of variance effect of Iron (Fe) stress on the observed character

Character	Varieties		Treatment		Interaction		CV (%)
	F value	Pr > F	F value	Pr > F	F value	Pr > F	
Plant Height	23.75	<.0001**	0.22	0.6428^{ns}	0.11	0.9998^{ns}	9.30
Number of Leaves	9.83	<.0001**	2.01	0.1625^{ns}	0.6	0.8223^{ns}	17.06
Number of Productive Tillers	14.48	<.0001**	1.06	0.3078^{ns}	0.35	0.9699^{ns}	18.18
Root Length	5.63	<.0001**	0.48	0.4913^{ns}	0.88	0.5634^{ns}	16.72
Root Volume	9.34	<.0001**	1.27	0.2653^{ns}	1.93	0.0584^{ns}	23.19
Panicle Length	29.26	<.0001**	0.03	0.8619^{ns}	0.57	0.8438^{ns}	7.41
Weight of Filled grains (t)	1.45	0.1819^{tn}	0.23	0.6301^{ns}	0.93	0.5226^{ns}	23.49
Number of Filled grains (t)	2.89	0,0054**	0.33	0.5685^{ns}	0.92	0.5335^{ns}	20.75
Number of Empty grains	12.1	<.0001**	1.56	0.2180^{ns}	0.74	0.6909^{ns}	24.26
Flowering Time	12.89	<.0001**	0.03	0.8615^{ns}	0.35	0.9698^{ns}	4.12
Harvest Time	2.56	0.0122*	0.06	0.9916^{ns}	0.9	0.55^{ns}	1.98

Description: ** :High significant; * :Significant; ns :Not significant; F value; Pr > F : *Probability Value* ; CV : Coefficient Variance; t: Transformation of data 'square root' = SQRT (original data + 0.5)

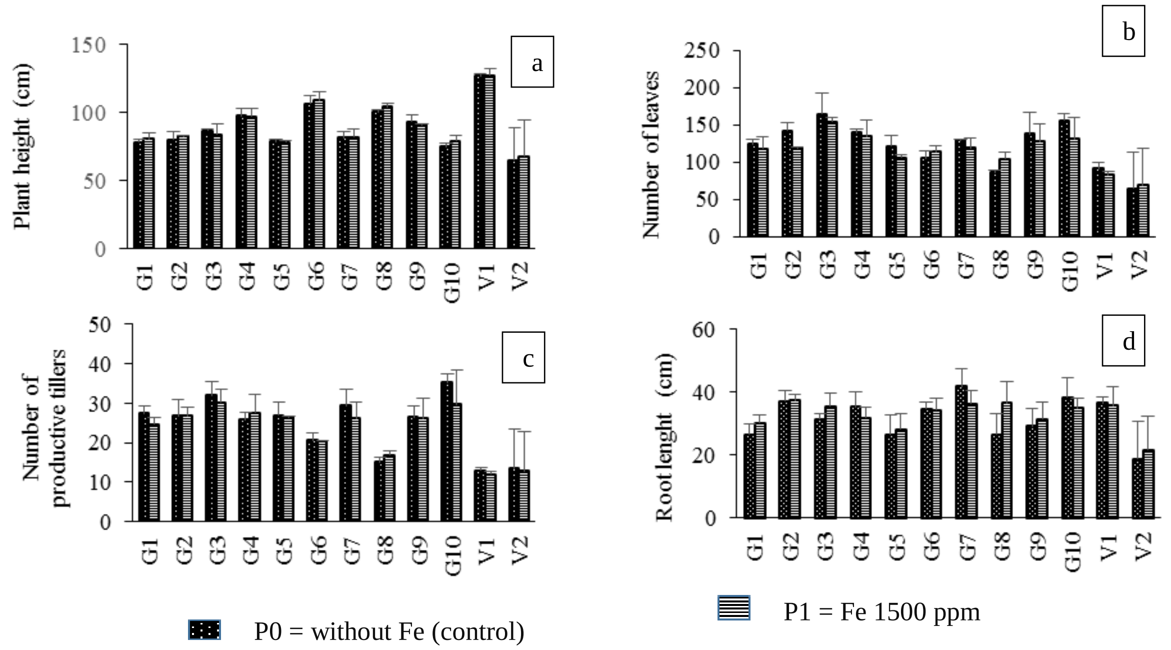

Figure 1. The growth of rice plants; (a) Plant Height; (b) Number of Leaves; (c) Number of Productive Tillers; (d) Root Length G1: 19I-09-30-17-17; G2: 19I-06-09-23-3; G3: 21B-57-21-21-1; G4: 21B-57-21-21-25; G5: 19I-06-30-17-27; G6: 23A-56-30-25-1; G7: 19I-06-09-23-27; G8: 23A-56-30-25-13; G9: 23A-56-30-25-12; G10: 23A-56-24-22-12; V1: Danau Gaung; V2: Banyuasin

Table 4. Average character of upland rice genotype with Fe stress treatment

Lines	Character									
	Plant Height (cm)	Number of Leaves (strands)	Number of Productive Tillers	Root Length (cm)	Root Volume (mL)	Panicle Length (cm)	Number of Filled grains	Number of Empty grains	Flowering Time (days)	Harvest Time (days)
19I-09-30-17-17	79.35^{e}	120.75^{bcd}	26.02^{b}	28.39^{c}	40.25^{g}	16.08^{d}	861.00^{cd}	12.43^{bc}	75.62^{b}	112.67^{a}
19I-06-09-23-3	81.40^{e}	130.33^{bcd}	26.77^{b}	37.28^{ab}	87.67^{abc}	16.89^{dc}	2305.80^{a}	10.74^{c}	69.00^{d}	112.00^{a}
21B-57-21-21-1	85.55^{de}	159.37^{a}	31.1^{ba}	33.60^{abc}	78.67^{abcd}	16.02^{d}	1499.00^{b}	13.49^{bc}	80.70^{a}	112.80^{a}
21B-57-21-21-25	97.22^{c}	137.00^{abc}	26.73^{b}	33.69^{abc}	82.00^{abc}	16.51^{d}	1485.50^{b}	10.35^{c}	75.10^{b}	112.33^{a}
19I-06-30-17-27	78.37^{e}	113.63^{cde}	26.73^{b}	27.43^{c}	46.53^{fg}	16.34^{d}	873.60^{cd}	10.19^{c}	74.53^{b}	112.13^{a}
23A-56-30-25-1	107.73^{b}	109.20^{def}	20.50^{c}	34.52^{abc}	73.67^{bcd}	20.32^{b}	1384.40^{b}	22.71^{abc}	67.83^{d}	111.67^{a}
19I-06-09-23-27	81.83^{e}	124.00^{bcd}	27.77^{ab}	39.16^{a}	90.67^{ab}	16.29^{d}	2106.00^{a}	5.34^{c}	73.37^{bc}	112.33^{a}
23A-56-30-25-13	102.30^{bc}	95.00^{ef}	16.00^{dc}	$31{,}71^{bc}$	51.33^{efg}	19.84^{b}	1202.30^{bc}	34.75^{ab}	69.17^{d}	107.73^{b}
23A-56-30-25-12	92.23^{cd}	132.60^{bcd}	26.27^{b}	30.45^{bc}	61.00^{def}	18.20^{c}	1427.00^{b}	34.74^{ab}	74.50^{b}	111.67^{a}
23A-56-24-22-12	76.88^{e}	143.43^{ab}	32.47^{a}	36.79^{ba}	68.33^{cde}	13.44^{e}	1358.90^{b}	16.71^{abc}	70.67^{cd}	112.83^{a}
Danau Gaung	127.10^{a}	87.00^{fg}	12.43^{d}	36.23^{ba}	95.27^{a}	24.32^{a}	1570.90^{b}	55.33^{a}	76.30^{b}	110.47^{a}
Banyuasin	66.50^{f}	66.80^{g}	13.05^{d}	20.23^{d}	41.18^{fg}	15.37^{d}	650.00^{d}	12.99^{c}	82.22^{a}	112.86^{a}

Description: The numbers followed by the same letter in the same column show no distinct apparent on the DMRT (*Duncan Multiple Range Test)* level of 95%

. Line 19I-06-09-23-27 in plants with Fe stress had a lower volume compared to plants without Fe stress. The average length of panicle did not show high different results between plants that were Fe stress with plants without Fe stress (Figures 2a and 2b).

The weight of filled grains and the number of filled grains there was not a high difference between plants with Fe stress and without Fe stress treatment. The number of empty grains on plants with Fe stress and without stress also showed that was not significant different results. The average flowering time and harvest time showed that was not significant different between plants with Fe stress and without Fe stress treatment (Figure 2e, 2f, 2g).

The correlation test resulted at the level of 1% (Table 5) showed that positive correlated was height plants with the number of filled grains, correlation between lenght of panicle with the number of filled grains, the correlation between height plant and length of panicle, number of leaves with number of productive tillers, and the length of roots with the volume of roots including positive correlations.

The genotype character of rice plants that correlates to 5% level were plant height that was correlated with volume of roots, number of leaves is correlated with the length of the roots, and number of productive tillers correlates with harvest time. These characters showed a positive correlation that was classified as a moderate correlation.

Observation of Iron poisoning symptoms against all rice plants showed that all lines of red rice had same criteria for iron stress tolerant. Iron (Fe) scoring against all lines of red rice and two comparison varieties has a score of 1 (highly tolerant) on all rice plant. Plants categorized as score 1 (highly tolerant) were observed based on yellow to brown patches on the leaves (bronzing), root color, plant height, and number of tillers.

Qualitative character observation resulted there were 3 criteria of leaf color, namely Moderate Yellow Green C, Moderate Olive Green A, and Moderate Olive Green B (Table 6). The color of the leaves consisted of Moderate Yellow Green C with a population of 54 population namely lines 19I-09-30-17-17, 19I-06-09-23-3, 21B-57-21-21-1, 19I-06-30-17-27, 23A-56-30-25-1, 19I-06-09-23-27, 23A-56-30-25-13, 23A-56-24-22-12, and Danau Gaung varieties. Moderate Olive Green A leaf color consists of 6 plant populations of lines 21B-57-21-21-25 and Moderate Olive Green B color consists of 12 populations of lines 23A-56-30-25-12 and Banyuasin varieties (Table 6).

The observed root colors of the entire population were Light Yellow C, Moderate Yellow B, Moderate Yellow A, and PaleYellow C (Table 6). Light Yellow C root color was as many as 18 plant populations consisting of lines 19I-09-30-17-17, 19I-06-09-23-3, and varieties of Danau Gaung. Moderate Yellow B root color with 42 populations of lines 21B-57-21-21-25, 19I-06-30-17-27, 23A-56-30-25-1, 23A-56-30-25-13, 23A-56-30-25-12, 23A-56-24-22-12, and Banyuasin varieties. The root colors of Moderate Yellow A and PaleYellow C each consisted of 6 plant populations from line 21B-57-21-21-1 and 6 populations of line 19I-06-09-23-27 (Table 6).

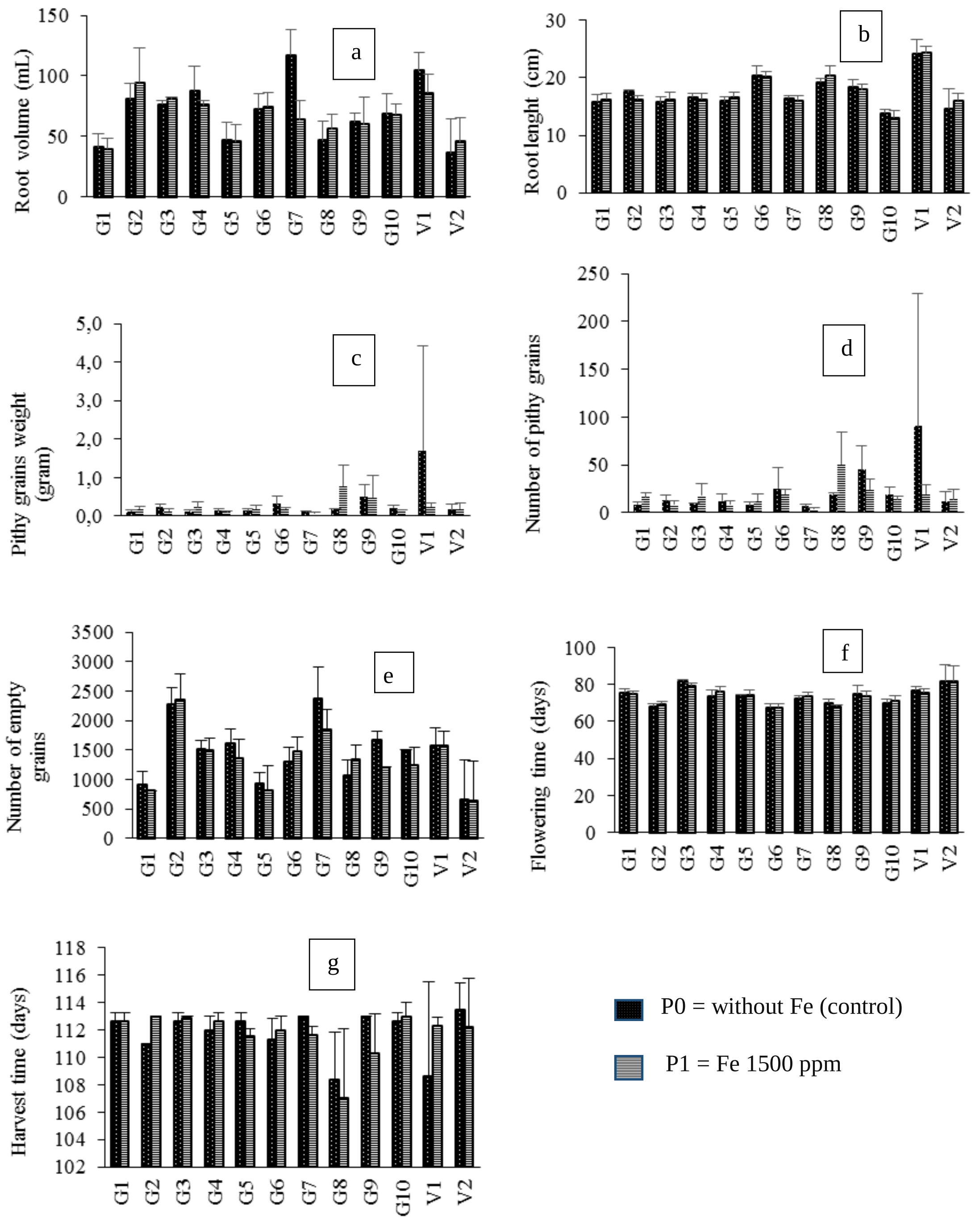

Figure 2. The growth of rice plant; (a) Root Volume; (b) Panicle length; (c) Weight of Filled Grains; (d) Number of Filled Grains; (e) Number of Empty Grains; (f) Flowering Time; (g) Harvest Time; from genotype G1: 19I-09-30-17-17; G2: 19I-06-09-23-3; G3: 21B-57-21-21-1; G4: 21B-57-21-21-25; G5: 19I-06-30-17-27; G6: 23A-56-30-25-1; G7: 19I-06-09-23-27; G8: 23A-56-30-25-13; G9: 23A-56-30-25-12; G10: 23A-56-24-22-12; V1: Danau Gaung; V2: Banyuasin

Table 5. Correlation of genotype characters

Character	Character									
	Plant Height (cm)	Number of Leaves (strands)	Number of Productive Tillers	Root Length (cm)	Root Volume (mL)	Panicle Length (cm)	Number of Filled Grains	Number of Empty Grains	Flowering Time (days)	Harvest Time (days)
Plant Height (cm)	-									
Number of Leaves (strands)	-0.177									
Number of Productive Tillers	-0.450*	0.913**								
Root Length (cm)	0.392	0.497*	0.368							
Root Volume (mL)	0.447*	0.318	0.163	0.802**						
Panicle Length (cm)	0.909**	-0.412*	-0.654**	0.224	0.313					
Number of Filled grains	0.619**	-0.221	-.0430*	0.166	0.214	0.664**				
Number of Empty grains	0.227	0.445*	0.323	0.812**	0.832**	0.149	0.028			
Flowering Time (days)	-0.273	-0,143	-0.132	-0.559**	-0.199	-0.198	-0.071	-0.413*		
Harvest Time (days)	-0.517**	0.299	0.466*	-0.141	0.020	-0.586**	-0.617**	0.024	0.373	-

Description: The number followed by the * symbol in the column shows a significant correlation at the level of 5 %. The number followed by the ** symbol in the column indicates a significant correlation at the rate of 1 %. Correlation values 0.00-0.20 (no correlation), 0.21-0.40 (weak correlation), 0.41-0.60 (moderate correlation), 0.61-0.80 (strong correlation), 0.81-1.00 (perfect correlation) with Pearson Bivariate analysis

Table 6. Qualitative parameters of leaf color and root color of genotype rice plants gripped Fe 551.55 ppm

Lines	Leaf Color	Root Color
19I-09-30-17-17	Moderate Yellow Green C	Light Yellow C
19I-06-09-23-3	Moderate Yellow Green C	Light Yellow C
21B-57-21-21-1	Moderate Yellow Green C	Moderate Yellow A
21B-57-21-21-25	Moderate Olive Green A	Moderate Yellow B
19I-06-30-17-27	Moderate Yellow Green C	Moderate Yellow B
23A-56-30-25-1	Moderate Yellow Green C	Moderate Yellow B
19I-06-09-23-27	Moderate Yellow Green C	PaleYellow C
23A-56-30-25-13	Moderate Yellow Green C	Moderate Yellow B
23A-56-30-25-12	Moderate Olive Green B	Moderate Yellow B
23A-56-24-22-12	Moderate Yellow Green C	Moderate Yellow B
Danau Gaung	Moderate Yellow Green C	Light Yellow C
Banyuasin	Moderate Olive Green B	Moderate Yellow B

Description : Observation of leaf color and root color based on RHS *colour chart*

DISCUSSION

Fe stress on the lines and varieties of upland rice plants did not have a different effect on the growth of rice plants. Analysis of variance results showed that Fe stress treatment had no significant effect on rice growth. In contrast to fe's treatment, plant varieties affected all characters of rice plant except the weight of filled grains (Table 2). According to Suryadi et al. (2010) each variety has different genetic potentials that result in diversity in responding to the growing environment such as Fe stress.

The resistance of lines to stress is thought to be due to the presence of tolerant genes derived from parental. Nugraha et al. (2017), the resistance of rice plant to Fe stress is controlled by many genes. Toding (2013) one of the genes controlling the nature of tolerance to iron (Fe) stress is the OsIRT gene. Test lines and check varieties that are thought to tolerant to Fe stress have the potential to have the OsIRT gene. According to Utami and Haranida (2014) the resistance of rice plant to Fe stress can be effectd by the presence of genes in OsIRT1 and OsIRT2. The growth of test lines and checkvarieties with Fe stress treatment and without treatment has almost the same growth. This suggests test lines and plant varieties can survive and grow well despite Fe stress. Based on the description of varieties of plants that Danau Gaung has resistance to iron (Fe) stress and Banyuasin varieties have a resistance of Fe (ICFRR 2011).

Fe stress treatment of rice plant showed the same tolerance level score of 1 (very tolerant) in each line tested. All lines tested have resistance to Fe stress, this is based on the results of observations of leaf color that does not show the presence of bronzing on the leaves marked by no yellow to brown patches. The roots of the entire rice lines also showed the absence of brown patches on the roots (Table 4). This indicates that the absence of symptoms of Fe poisoning in the lines tested. According to Mowidu et al. (2017) that plants gripped iron (Fe) will show symptoms in the form of brown patches on the roots, thickened roots, rough, and short, plants become dwarf, yellow to brown patches (*bronzing)* on tip of the leaves that will spread to the base of the leaves, and flowering inhibited. Identification of Fe poisoning symptoms can be used as a parameter for selecting genotypes that are tolerant to stress.

The nature of plant tolerance to Fe is an important factor for adapting to a sedative environment. Rice plant that are tolerant to Fe's stress have the ability to survive high fe concentration conditions. According to Mahender et al. (2019) plants will avoidance or tolerance of tissues to overcome high Fe concentrations. Tolerant plants can survive with enzymatic detoxification mechanisms to tolerate Fe^{2+} contained in plant tissues. Plants will avoid by oxidizing Fe^{2+} into Fe^{3+} and perform the mechanism of ion selectivity of the root cell membrane so that it does not absorb Fe^{2+}. According to (Noor & Khairuddin, 2013) Tolerant plants can also store Fe^{2+} absorbed in old root, stem, or leaf tissues as a form of avoidance of stress.

The height of each plant lines tested is varied. According to Sutaryo (2012) the height plant character will be more diverse along with the number of plant genotypes tested. Lines 23A-56-24-22-12 and 23A-56-30-25-1 have the shortest and highest plant heights compared to other test lines of 76.88 cm and 107.73 cm (Table 3). According to IRRI (2013) plants with a height of < 105 cm are included in short plants. Plant height 106-120 cm classified as a medium plant. According to Rahmah and Aswidinnoor (2013) short plants are potentially resistant to the grains that become parameters for the selection of superior genotypes.

The number of leaves is positively correlated with the number of productive tillers. The more the number of leaves will be the more productive the number of rice plant. The leaves are very influential on the number of productive rice plant. According to Fatimaturrohmah et al. (2016) the leaves will produce assimilation to form productive tillers, initiation of panicle, and seed filling to improve yields. The number of leaves becomes an important character in the growth of rice plant, disruption of photosynthesis process that occurs in the leaf due to Iron poisoning can affect the yield of plants. According to Amnal (2009) high concentrations of Iron in leaf tissue can reduce the number of tillers that can affect the yield of rice plant, in addition to the metabolic processes of plants disturbed by Iron poisoning can also change the character of agronomy and physiology of rice plant.

The number of productive tillers becomes an important character that determines the number of panicle, number of grain, and number of filled grain (Saniyati, 2012). Based on Rice Standard Evaluation System the number of productive tillers is classified into 5 categories, namely > 25 tillers (very high), 20-25 tillers (high), 10-19 tillers (medium), 5-9 tillers (low), and <5 tillers (very low) (IRRI 2013).

The tillers number of test lines is very high category, except for lines 23A-56-30-25-1 (20.50 tillers) with high categories and 23A-56-30-25-13 (16 tillers) of the medium category (Table 3). Fatimaturrohmah et al. (2016), the number of tillers is medium category but all the tillers are productive will be better because photosynthate can be directed to the formation of grain. The number of tilllers (medium) that are balanced with long panicle character also affects the number of grain to increase the production. This is in accordance with table 3 which shows the number of productive tillers in line 23A-56-30-25-13 is medium as having more number of filled grains than other lines. According to Shafi'ie et al. (2018) differences in the number of tillers in addition to genetic factors effectd by the number of tillers are also effectd by environmental factors such as planting distance, sunlight, and nutrients.

The root becomes an organ that plays an important role in the resistance to Fe stress. The length of the root indicates a significant correlation to volume of root. Long plant roots and wide distribution is expected to maximize in nutrient absorption. Roots are plant organs that can select nutrients that enter the tissues of plants. Fe-stress tolerant plants have the ability not to absorb excessive iron from the soil. The *lines* with the highest root length and volume is 19I-06-09-23-27 (Table 3). The length and volume of roots have a varied value. Analysis of variance results showed that plant varieties have a very significant effect on the length and volume of roots. factors namely genetic factors and environmental factors such as iron stress.

Observations of flowering time showed that line 21B-57-21-21-1 has the longest flowering time, in contrast to line 23A-56-30-25-1 that has the earliest flowering among other lines (Table 3). The test lines with the earliest harvest time is 23A-56-30-

25-13 which is different from other lines. According to ICFRR (2016) the harvest age is categorized into three namely early (<105-124 HSS), medium (125-150 HSS), and long (>151 HSS). The harvest time of all test lines is classified as early with harvest time ranging from 107.73-112.83 days (Table 3). The length or not of flowering time is strongly effected by the vegetative growth of plants. Safrida et al. (2019) states that differences in genetic properties of plants that cause different growth characteristics. According to Shafi'ie et al. (2018) the harvest time is also effectd by the number of tillers, length of panicle, and number of grain with panicle.

The length of malai lines 23A-56-30-25-1 and 23A-56-30-25-13 becomes the longest and different significant with other lines. The number of productive tillers can affect the lenght of panicle character. According to Shafi'ie et al. (2018) length of panicle will be shorter with the increasing number of tillers otherwise the number of tillers that are less panicle will be longer. This corresponds to the correlation between the number of productive tillers and the length of panicle that is negative correlated (Table 5).

Fatimaturrohmah et al. (2016) that panicle is too long will produce a lot of grain. A large grain but not supported by a sufficient supply of photosynate for the filling of grain can cause a high number of empty grains.

The highest number of filled grains are lines 23A-56-30-25-12 and 23A-56-30-25-13. The number of filled grains is strongly effected by the rate of plants photosynthesis to maximize the grains filling process. Azalika et al. (2018) a good rate of photosynthesis can help the grain filling process by transferring photosynthate. Sugiarto et al. (2018) the number of filled grain depends on the rate of photosynthesis of plants during the reproductive phase, photosynthate in the form of starch substances will be directed to filling the grain. Pradipta et al. (2017) the number and weight of filled grains in addition to being determined by genetic factors of the genotype itself is also determined by environmental factors such as the intensity of sunlight, temperature, and nutrients.

The number of empty grains in all test lines showed quite high ranging from 861 – 2305.80 bulir (Table 3). The large number of empty grains is suspected due to the effect of environmental factors.

Observation of root color on the rice plants that are gripping shows a light yellow to dark yellow color. This indicates that the rice plant given Fe stress are able to grow. Suryadi et al. (2010) rice plants that are gripping Fe on its surface will be dark brown to blackish. The change in root color indicates the accumulation of Fe in the root of the plant. Fe content contained on the surface of plant roots can inhibit the absorption of nutrients. Plants sensitive to Fe stress under conditions of severe poisoning from vegetative phase of the root will faster aging and die.

The results of observation of all test lines obtained two lines with the best yield and growth compared to other lines, namely 23A-56-30-25-12 and 23A-56-30-25-13. These lines include short plants that have the potential to lodging resistant. Lines 23A-56-30-25-12 and 23A-56-30-25-13 showed no symptoms of Fe poisoning indicating the plant was tolerant to Fe. The potential outcomes of lines 23A-56-30-25-12 and 23A-56-30-25-13 are also higher than other lines. The lines 23A-56-30-25-12 and 23A-56-30-25-13 have the potential to be developed because this lines has the character of plants that breeders want to be used as varieties.

CONCLUSSION

The tolerance test to iron (Fe) should that all lines of red rice F_6 on ultisol soils has a score 1 which indicates the stress tolerance of Fe at a concentration of 551,55 ppm Fe. The 23A-56-30-25-12 and 23A-56-30-25-13 lines were the best lines that were tolerant of 551,55 ppm iron (Fe) stress with the highest growth and yield.

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