Response of Indonesian rice varieties to iron toxicity under field and green house condition

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Abstract. Excess of reduced iron (Fe^{2+}) will affect the plant growth of rice when it is grown under waterlogged condition. Some rice genotypes have been identified tolerance to iron toxicity with different mechanism-type of tolerance. This study aims to identify the response of some rice genotypes to iron toxicity, and to evaluate their consistency in the greenhouse screening method and the field condition. The experiments were conducted in iron toxicity hotspot area, Banyuasin (South Sumatera) and the control as irrigated rice field was in Sukamandi (West Java). The green house experiment of Fe toxicity was done using 400 ppm of Iron with Yoshida Agar Solution method. The response of rice plant to iron toxicity was observed on leaf bronzing score (LBS), iron content and uptake, biomass, yield and yield components and stress tolerant index (STI). We found that there was not clear relationship between the iron content with the leaf bronzing symptom depending on type of tolerant while the stress tolerance index was corelated with the yield. There were two varieties was identified as tolerant, namely Cilamaya Muncul as includer tolerant genotype and Awan Kuning as the excluder tolerant genotype. The information of the distinct response those rice germplasms can be used for recommendation for further study and development of rice tolerant to iron toxicity condition.

1 Introduction

Rice is a semi-aquatic plant that can be grown on dry land and waterlogged conditions. Under irrigated rice farmer inundate the land from vegetative stage until maturity, to control the weeds and make condition more effective for fertilizers application. Under such conditions causes soil become anaerobic, where oxygen diffuses 10,000-fold lower in water than in the atmospheric condition [1]. The reduction of soil minerals is also enhanced by the existence of anaerobic microbes [2], converted from insoluble form of Fe^{3+} to soluble form and available to plants of Fe^{2+} [3].

Iron toxicity in rice is caused as an effect of excessive Fe^{2+} uptake and usually occurs at range of 1,000 – 2,000 ppm of Fe^{2+} that may affect rice grain yield [4,5]. Iron toxicity

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interferes metabolic processes and cause damage the rice plants organs, which is marked by leaf bronzing symptoms, delayed of flowering, inhibited assimilate processes, dwarfed of plant posture, less developed of root system, decayed, roughed and shorted of stems and leaves [6,7]

Rice plant can develop a mechanism of avoidance or tolerance both morphologically and physiologically to survive on soil conditions with high iron solubility. Four types of plant adaptation to iron toxicity [8], such as 1) Avoidance inclusion, roots remove iron to avoid damage of shoot tissue by oxidation in the zone of rhizosphere or through mechanism of root selectivity to ion [9, 10], or increased pH of soil solution with OH efflux to decrease Fe^{2+} activity [11]; 2) Avoidance inclusion, iron absorbed by roots but damage of plant tissues may be avoided by compensation such as leaves that are not actively photosynthesized [12], or stored in cell vacuoles, iron storage proteins [13, 14]; 3) Tolerant inclusion, plant is able to tolerate iron into the shoot tissue by detoxifying enzymatically effects of iron toxicity [14, 15]; 4) Membrane selectivity through transporter protein Iron Regulated Transporter [16].

There have been reported that some Indonesian rice have tolerance to iron toxicity, i.e., Inpara 2, Inpara 3 [17]; Inpara 8, Inpara 9, Inpara 10 (Certificate of National Released Variety) however, there is still lack of study regarding mechanism response of rice genotypes to iron toxicity under the field and compared to the green house condition, especially in partitioning iron uptake in the shoot and root and its correlation to the browsing symptom. This study aims to identify response of some rice genotypes to iron toxicity, and to evaluate consistency of greenhouse screening method and field condition under the iron stress in rice plant.

2 Methodology

The experiment was conduct in three locations, that were tidal swamp (Telang Lago, Banyuasin) which is iron-stressed hotspot area, normal condition (Sukamandi Experimental Station), and greenhouse of Indonesian Center for Rice Research. Twenty rice genotypes consist of local varieties, swamp and irrigated varieties were used in the field and greenhouse experiment (Table 1). The field experiment was designed using randomized block design with three replications. Every genotype was planted in 7 m^2 of plot size with 25 cm x 25 cm of plant spacing. Response of plant to iron toxicity was observed on variable of leaf bronzing symptom, plant height, biomass, yield, and yield component.

The greenhouse experiment was designed using augmented design. There was two set of greenhouse experiment, which was stress condition and optimal condition. Screening method for iron toxicity using Yoshida Agar Solution with 300 ppm of $FeSO_4.7H_2O$ [18]. The leaf bronzing score (LBS) were determined using scoring index scale, based on bronzing symptoms in leaves [19] at the fifth and tenth days after Fe^{2+} treatments. The relative yield performance of genotypes in iron stressed and non-stressed environment can be used as an indicator to identify tolerant genotypes. A stress tolerance index was defined as [20]:

$$STI = \frac{((\boldsymbol{Y_i})_{\boldsymbol{NS}}\ \boldsymbol{X}\ (\boldsymbol{Y_i})_{\boldsymbol{S}})}{\boldsymbol{Y}^2_{\boldsymbol{NS}}}$$

STI = stress tolerant index, Y_i NS = yield under normal condition, Y_i S = yield under stress condition. This formula can be used to identified genotypes that produce high yield under both stress and non-stress environment. High value of STI indicate high tolerance of stress. The genotype has STI value higher relatively than others was indicate more tolerant.

Fe content analysis to explain whether iron was accumulated in the body of rice plant. Iron should be translocated from rhizosphere by the root and should be allocated through xylem into the grain [20]. Tolerance-typed to iron toxicity can be categorized into two types namely, exclusion and inclusion tolerance-type. This identification can be done simply by checking the presence of Fe^{2+} in the shoots and root of rice plant [21-23]. Shoot and root iron content, and iron uptake was analyzed using wet destruction with HNO_3 and $HClO_4$ (methods). Sample of shoot and root were harvested in vegetative phase. As much as 0.25 g of sample + 2.5 ml HNO_3 + 2.5 ml $HClO_4$ put into the kjedahl flask, and stirred overnight. The next day, the solution was digested/heated for four hours. The solution was diluted into 50 ml volumetric flask for overnight, and the next day the new solution/extract was measured using Atomic Absorption Spectroscopy (AAS).

The Experiment data were analyzed using combined analysis of variance across environment, and correlation analysis. Analysis of variance (ANOVA) for combined sites followed method described by Fehr [24]. The differences between genotypes were analyzed using Least Significant Different with $\alpha = 5\%$. All statistical procedure were analyzed using STAR 2.0.1 and SAS 9.4 software.

Table 1. Genetic materials for iron toxicity screening in Telang Lago, Sukamandi, and Green House. Wet Season of 2016.

No	Genotype	Agroecosystem	No	Genotype	Agroecosystem
1	Siam Mutiara	Local variety	11	Inpara 1	Swampy area
2	Siam Unus	Local variety	12	Inpara 2	Swampy area
3	Mahsuri	Introduction variety (tolerant check)	13	Inpara 3	Swampy area
4	Mekongga	Irrigated	14	Inpara 4	Swampy area
5	Ciherang	Irrigated	15	Inpara 5	Swampy area
6	Cilamaya Muncul	Irrigated	16	Inpara 6	Swampy area
7	Pokkali	Introduction variety	17	Inpara 7	Swampy area
8	IR 64	Irrigated (sensitive check)	18	Inpara 8	Swampy area
9	Siak Raya	Swampy area	19	Inpara 9	Swampy area
10	Inpari 30	Irrigated	20	Awan Kuning	Local variety

3 Result and discussion

3.1 Iron content and iron uptake

Iron content in shoot and root at the Yoshida Agar Solution was higher than in the stressed field condition (Banyuasin). Nevertheless, the iron uptake on Yoshida Agar Solution was lower than field stress condition (Figure 1). IR64 is the lowest iron content in the root compared to others genotypes, which mean iron did not accumulate in the root. While Cilamaya Muncul was the highest iron content in the shoot which mean iron was transported from the root to the shoot. All genotypes show similar response of iron content and iron uptake. Iron content mean that total iron identified in the plant organ, while iron uptake means only ferrous iron (Fe^{2+}) that identified in the plant organ which mean that in can be transportable. The screening of iron toxicity using Yoshida Agar Solution was effective to bind iron oxidation. Screening in seedling stage is effective and efficient for breeders to select very large early generation breeding materials [18]. This method does not require large of area, because selection for early generations have not yet consider on yield character. Therefore, in the next advanced generation of breeding materials need to be confirm its tolerance based on Yield Trials in iron-stress area. The result showed that iron content in the root were higher than the shoot in both green house and field. This result was similar to those reported that one of adaptive mechanism was aim to exclude iron into shoot and hold it in rhizosphere through capability of roots oxidizing iron before being absorbed [8,10,23,25,26].

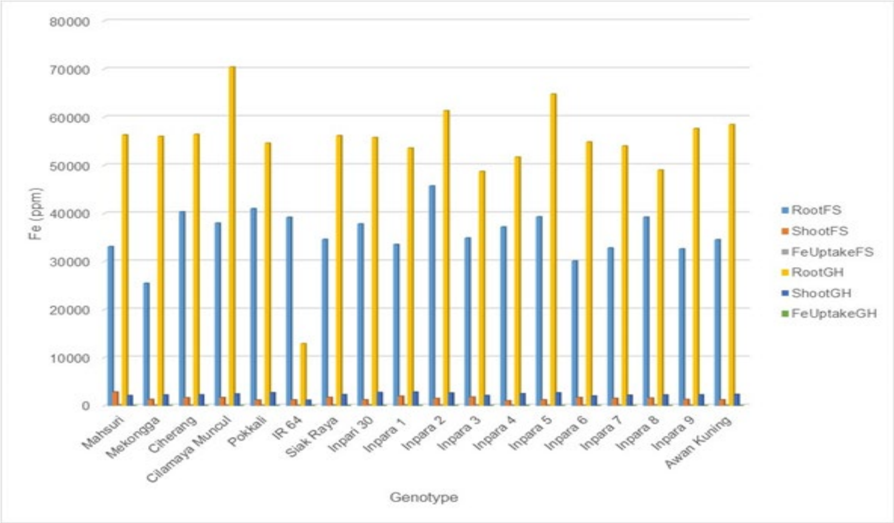

Fig. 1. Iron uptake and iron content in root and shoot. FS; Field stress = Banyuasin, GH; Green House (Yoshida Agar Solution).

The ANOVA in field condition showed that the effect of genotype was an insignificant different on iron content in root and shoot, but it was significantly different in iron uptake. All genotypes showed the presence of iron content resulted an insignificantly difference between tolerant and sensitive genotypes, or inclusion mechanism was predominantly working in response iron toxicity based on iron uptake (Table 2).

Table 2. Iron uptake and iron content in root and shoot under field condition. Banyuasin, WS of 2016

No	Genotype	Iron content (ppm)		Iron uptake (ppm)	LBS
		Root	Shoot		
1	Siam Mutiara	35.474	1.918	150	5
2	Siam Unus	42.757	1.432	82	1
3	Mahsuri	33.083	2.843	169	5
4	Mekongga	25.444	1.306	77	3
5	Ciherang	40.290	1.653	70	5
6	Cilamaya Muncul	37.949	1.678	90	3
7	Pokkali	40.976	1.169	68	5
8	IR 64	39.162	1.200	58	3
9	Siak Raya	34.583	1.722	128	5
10	Inpari 30	37.788	1.223	146	7
11	Inpara 1	33.515	1.978	147	5
12	Inpara 2	45.699	1.504	97	5
13	Inpara 3	34.863	1.796	127	5
14	Inpara 4	37.169	1.022	69	5
15	Inpara 5	39.268	1.215	63	5
16	Inpara 6	30.073	1.680	73	5
17	Inpara 7	32.778	1.519	92	3
18	Inpara 8	39.213	1.578	147	5
19	Inpara 9	32.600	1.281	87	3
20	Awan Kuning	34.528	1.222	91	3
	LSD (5%)	ns	ns	73	
	CV (%)	18.3	19.5	34.4	

Note: 1: tolerant, 3: moderate tolerant, 5: (moderate sensitive), 7: sensitive, 9: very sensitive

Mahsuri as a tolerant check was the highest iron content in shoot compared to others, and although it was considered as moderate sensitive (score 5 of LBS). Siam Unus and Cilamaya Muncul has a relatively high iron content in root and a lower LBS score than Mahsuri. INPARI 30 had lower iron content, but it had higher LBS (sensitive), which mean that the cell was decay because of iron excess. However, it has been reported that in some case of rice genotypes, iron content in plant tissue was not always correlated with symptom scores [8]. This shows the difference between visual symptom and Fe concentration in leaves, hence forward it can be distinguished whether genotypes adaptive to excess of iron condition due to avoidance or accumulation of Fe in leaves.

Iron content and iron uptake in the Yoshida Agar Solution were insignificant different among genotypes. However, IR 64 (sensitive check) had a relatively lower iron content and iron uptake than others. Cilamaya Muncul had relatively high in iron content, but its iron uptake was relatively lower than others. Leaf bronzing symptom of Cilamaya Muncul was also the lowest, even the scale showed no symptom at 10 days after stress. This result was similar to the field stress condition, where Cilamaya Muncul had iron content relatively higher but lower in LBS score (Table 3). Based on the iron content and LBS score, Cilamaya could be classified as includer tolerant, which means that the genotype can tolerate to iron into shoot tissue by detoxifying enzymatically effect of iron toxicity.

Table 3. Iron uptake and iron content in root and shoot under Yoshida Agar Solution. Green house WS of 2016

No	Genotype	Iron content (ppm)		Iron uptake (ppm)	LBS	
		Root	Shoot		10 DAS	17 DAS
1	Siam Salaka	114.002	3.317	3.53	3	5
2	Siam Unus	113.806	3.670	2.92	3	7
3	Mahsuri	110.326	3.763	3.20	3	7
4	Mekongga	106.852	3.899	4.39	5	7
5	Ciherang	110.879	3.800	3.57	5	7
6	Cilamaya Muncul	138.315	4.472	0.48	0	5
7	Pokkali	107.171	4.879	6.68	3	7
8	IR 64	86.676	2.911	1.68	3	7
9	Siak Raya	110.132	3.994	5.01	3	7
10	Inpari 30	109.482	4.543	4.62	3	7
11	Inpara 1	105.069	4.943	5.76	3	7
12	Inpara 2	120.636	4.740	4.62	3	9
13	Inpara 3	95.323	3.438	3.85	3	7
14	Inpara 4	101.698	4.523	5.54	3	5
15	Inpara 5	126.047	4.647	4.64	3	5
16	Inpara 6	107.632	3.601	3.67	3	5
17	Inpara 7	105.560	3.769	4.75	3	5
18	Inpara 8	96.126	3.863	6.08	3	5
19	Inpara 9	113.318	3.905	4.06	3	5
20	Awan Kuning	114.576	4.269	4.31	3	5
	CV (%)	19.6	18.7	19.6		

Note: 1: tolerant, 3: moderate tolerant, 5: (moderate sensitive), 7: sensitive, 9: very sensitive

Based on LBS and Fe content in the tissues, scientist defines two types of tolerant varieties, that were the includers which have a high Fe content but low leaf bronzing and the excluders which have a low Fe content and low leaf bronzing [4]. Cilamaya Muncul and Siam Unus was identified as includer tolerant because it has high iron concentration both in plant tissue in stress condition in nutrient culture and in iron-toxicity hotspot area (Banyuasin) and showed low leaf bronzing symptom. All Inpara series (except for Inpara 2 and 3) and Awan Kuning had low LBS scores (moderate tolerant) under Yoshida Agar Solution as well as in the field conditions. Inpara 7. Inpara 8 and Awan Kuning could be assumed as excluder tolerant. However, it should be considered that iron content is not always correlate with tolerance level [4, 22]. Under field stress conditions, iron content in roots was not correlated with iron content in shoot and the iron uptake. Iron content in shoot was correlated with iron uptake. Under Yoshida Agar Solution. Iron content in the roots was correlated with iron content in shoot but not correlation with iron uptake. Meanwhile, there was correlation between iron content and iron uptake (Table 4).

Table 4. Correlation between iron content and iron uptake

	Field condition		**Yoshida Agar Solution**	
	Fe-Shoot	**Fe-uptake**	**Fe-Shoot**	**Fe-uptake**
Fe-Root	-0.223	-0.148	0.468*	-0.305
Fe-Shoot		0.696**		0.491*

3.2 Genotype x iron toxicity interaction on yield and yield component

The response of genotype under iron toxicity in the field condition (Banyuasin) and normal condition (Sukamandi) was to compare reduction of performance under iron stressed compared to non-stressed environment, which can be used as an indicator economically judgment of tolerance genotypes [2]. According to the combined analysis of variance, the effect of stress conditions on the number of filled grain and unfilled grains, dry weight of shoot and root, yield and weight of 1000-grains were bid difference. Meanwhile, the effect of genotype was different on all observed characters. Effect of genotype x stress condition interaction was different on number of productive tillers, number of filled and unfilled grain, dry weight of shoot and root, weight of 1000 grain, and yield (Table 5 and 6). It means that genotypes tested have different response of reduction of yield grain, yield components, and also dry weight of shoot and root.

Table 5. Anova of plant height, number of productive tillers, number of filled and unfilled grains of rice genotype under stress and normal condition

Source of variance	**DF**	**Plant height**		**No. of productive tillers**		**No. of filled grain**		**No. of unfilled grain**	
		MS	**Pr(> F)**	**MS**	**Pr(> F)**	**MS**	**Pr(> F)**	**MS**	**Pr(> F)**
Site	1	1959.26	0.155	194.68	0.276	5320.04	**0.01**	30737.81	**0.00**
Rep/site	4	639.54	0.007	122.24	0.000	215.21	0.69	128.91	0.73
Genotype	17	644.91	0.000	31.06	0.000	885.67	0.01	1445.37	0.00
Genotype x site	17	143.20	0.608	32.56	**0.000**	702.12	**0.04**	550.50	**0.01**
Pooled Error	68	164.25		8.38		380.71		252.32	
Total	107								

Table 6. Anova of plant height, dry weight of shoot and root, yield and weight of 1000 grains of rice genotype under stress and normal condition

Source of variance	**DF**	**Dry weight of shoot**		**Dry weight of root**		**Yield**		**Weight of 1000 grains**	
		MS	**Pr(> F)**	**MS**	**Pr(> F)**	**MS**	**Pr(> F)**	**MS**	**Pr(> F)**
Site	1	134323.68	**0.00**	3238.46	**0.01**	34.96	**0.04**	86.05	**0.03**
Rep/site	4	1561.95	0.01	155.74	0.04	3.61	0.00	7.18	0.03
Genotype	17	949.33	0.02	158.38	0.00	3.02	0.00	21.09	0.00
Genotype x site	17	1001.06	**0.01**	122.10	**0.02**	2.12	**0.00**	24.45	**0.00**
Pooled Error	68	451.45		59.72		0.61		2.45	
Total	107								

Response of plant height under iron toxicity and optimal conditions was scanty varied, although the interaction of genotype x stress condition was insignificant (Table 6). This variation may be low so it could not arise interaction. The number of productive tillers of genotypes varies from normal to stress condition. Not all genotypes had decreased in the number of tillers under stressed condition while all genotypes decreased in dry weight of shoot and root from normal to stress. The average of number of grains per panicle in normal condition was relatively less than the in stress condition. This might be caused severely attacked by bacterial leaf blight and smell bug (*Leptocorisa oratorius*) during grain filling. However, the weight of 1000 and dry weight of shoot and root of normal condition was higher compared to stress conditions which also contributed to the grain yield (Table 7).

Table 7. Plant height, number of productive tillers, dry weight of shoot and root of rice genotype under iron toxicity and normal condition

No	Genotype	Plant height (cm)			No. of tiller			Dry weight of shoot (g)			Dry weight of root (g)		
		Normal	Stress	Mean	Normal	Stress	Mean	Normal	Stress	Mean	Normal	Stress	Mean
1	Siam Mutiara	131	110	120	21	16	19	59.5	20.6	40.1	26.5	16.9	21.7
2	Siam Unus	113	85	99	15	20	17	52.8	12.0	32.4	18.5	9.1	13.8
3	Mahsuri	132	117	125	19	16	17	84.2	16.0	50.1	19.6	10.4	15.0
4	Mekongga	107	97	102	17	16	16	68.1	14.6	41.3	11.3	8.8	10.0
5	Ciherang	110	115	113	17	14	15	75.3	14.5	44.9	14.5	7.3	10.9
6	Cilamaya Muncul	96	98	97	12	17	14	48.7	16.1	32.4	11.2	8.4	9.8
7	Pokkali	109	124	116	7	11	9	58.1	16.7	37.4	11.8	8.3	10.1
8	IR 64	102	90	96	23	14	18	73.6	10.1	41.8	19.6	7.2	13.4
9	Siak Raya	122	105	113	23	15	19	88.4	15.1	51.8	17.8	8.8	13.3
10	Inpari 30	107	98	102	11	14	12	107.3	11.6	59.4	24.2	7.7	15.9
11	Inpara 1	97	93	95	12	16	14	59.8	16.8	38.3	8.8	7.0	7.9
12	Inpara 2	120	103	112	17	11	14	73.4	19.9	46.7	10.5	6.3	8.4
13	Inpara 3	110	109	110	13	12	13	143.9	14.8	79.4	40.7	9.0	24.9
14	Inpara 4	94	81	87	19	9	14	70.6	14.5	42.5	17.2	8.0	12.6
15	Inpara 5	111	107	109	16	12	14	77.6	17.0	47.3	10.8	8.5	9.6
16	Inpara 6	128	109	118	15	11	13	118.2	16.7	67.4	25.4	8.8	17.1
17	Inpara 7	107	107	107	14	16	15	74.0	19.5	46.7	17.9	10.0	13.9
18	Inpara 8	134	116	125	18	11	15	95.1	14.2	54.6	14.3	8.3	11.3
19	Inpara 9	127	107	117	16	12	14	113.2	16.0	64.6	24.1	7.0	15.5
20	Awan Kuning	117	102	110	19	12	16	120.9	16.5	68.7	33.8	11.2	22.5
	Mean	114	104	109	16	14	15	83.1	15.7	49.4	18.9	8.8	13.9
	CV (%)	7	16	12	18	24	20	35		41.8	48.3	31.1	55.8
	LSD (5%)	13	27	15	5	5	4.7	48	0.45	34.6	15.1	0.4	12.6

Grain yield under normal conditions was ranged from 1.72 to 6.02 t/ha (Table 8). The plant attacked by pest and diseases during maturing. Grain yield of Inpara 6 and Inpara 9 have higher than Mahsuri. Grain yield under stress condition was ranged fron 1.71 to 2.86 t/ha. Mahsuri (tolerant check) has a yield of 2.86 t/ha. Cilamaya Muncul, Inpara 9, and Awan Kuning have grain yield which not significantly different with Mahsuri.

The ability of genotypes to perform reasonably well in iron toxicity stress is paramount for stability of grain yield. The relative yield performance of genotypes in iron toxicity stressed and non-stressed environments can be used as an indicator to identify tolerant genotypes. STI is a measure of tolerance degree of genotype to stress. Genotype with a higher value is considered more tolerant. Based on the STI, the tolerant genotypes were Mahsuri, Inpata 9, and Awan Kuning. Based on STI and LBS score, Cilamaya Muncul can also be identified as tolerant genotype (Table 9).

Table 8. Number of filled, weight of 1000 grains of rice genotype under iron toxicity and normal condition

No	**Genotype**	**No. of filled grain**			**Weight of 1000 grain (g)**		
		Normal	**Stress**	**Mean**	**Normal**	**Stress**	**Mean**
1	Mahsuri	61	67	64	17.8	26.2	22.0
2	Mekongga	65	53	59	28.8	24.9	26.9
3	Ciherang	48	47	48	28.2	23.6	25.9
4	Cilamaya Muncul	46	83	65	25.7	25.6	25.6
5	Pokkali	52	50	51	32.8	27.4	30.1
6	IR 64	68	67	67	26.8	24.9	25.9
7	Siak Raya	50	82	66	28.5	24.1	26.3
8	Inpari 30	56	40	48	28.8	21.4	25.1
9	Inpara 1	52	66	59	27.2	25.9	26.5
10	Inpara 2	63	74	69	29.5	24.5	27.0
11	Inpara 3	20	69	44	24.7	26.0	25.4
12	Inpara 4	25	91	58	21.2	27.6	24.4
13	Inpara 5	43	52	48	27.8	26.1	27.0
14	Inpara 6	64	74	69	26.2	23.1	24.6
15	Inpara 7	46	78	62	29.0	26.6	27.8
16	Inpara 8	80	94	87	30.7	25.0	27.9
17	Inpara 9	43	56	49	26.2	24.7	25.4
18	Awan Kuning	88	81	84	22.6	22.8	22.7
	Mean	54	68	61	26.8	25.0	25.9
	CV (%)	40.6	23.4	32	5.0	7.2	6.04
	LSD (5%)	36	27	32	2.2	3.0	2.55

Table 9. Grain yield, Stress Tolerant Index, and leaf bronzing score of rice genotype under iron toxicity and normal condition

No	**Genotype**	**Yield (t/ha)**			**STI**	**LBS-field stress**	**LBS-greenhouse**	
		Normal	**Stress**	**Mean**			**I**	**II**
1	Mahsuri	4.39	2.86	3.62	1.17	5	3	7
2	Mekongga	2.66	2.42	2.54	0.61	3	5	7
3	Ciherang	2.61	2.58	2.60	0.63	5	5	7
4	Cilamaya Muncul	2.88	2.64	2.76	0.71	3	0	5
5	Pokkali	3.25	2.30	2.78	0.70	5	3	7
6	IR 64	3.49	2.20	2.84	0.72	3	3	7
7	Siak Raya	3.62	2.25	2.93	0.76	5	3	7
8	Inpari 30	1.72	1.70	1.71	0.27	7	3	7
9	Inpara 1	2.07	2.15	2.11	0.42	5	3	7
10	Inpara 2	3.72	1.61	2.67	0.56	5	3	9
11	Inpara 3	2.75	2.31	2.53	0.59	5	3	7
12	Inpara 4	2.11	1.72	1.91	0.34	5	3	5
13	Inpara 5	1.90	1.67	1.78	0.30	5	3	5
14	Inpara 6	6.02	1.77	3.89	0.99	5	3	5
15	Inpara 7	1.88	1.64	1.76	0.29	3	3	5
16	Inpara 8	3.70	1.38	2.54	0.48	5	3	5
17	Inpara 9	5.13	2.63	3.88	1.26	3	3	5
18	Awan Kuning	4.92	2.53	3.72	1.17	3	3	5
	Mean	3.27	2.13	2.70				
	CV (%)	24.2	33.7	28.98				
	LSD (5%)	1.31	1.24	1.27				

4 Conclusion

We observed that there was distinct response of the rice genotypes based on the iron content in plant tissue, leaf bronzing symptom, and stress tolerance index, Cilamaya Muncul was identified as includer tolerant genotype. Awan Kuning was identified as the excluder tolerant genotype. Other genotype tolerances (Inpara 4, Inpara 7, Inpara 8, and Inpara 9) still need to be reconfirmed the consistency of the tolerance.

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