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Volume 2462

The Second International Conference on Genetic Resources and Biotechnology

Harnessing Technology for Conservation and Sustainable Use of Genetic Resources for Food and Agriculture

Bogor, Indonesia • 24–25 May 2021

Editors • I Made Tasma, Dwinita Winkan Utami, Ika Roostika, Yadi Suryadi, Chaerani, Eny Ida Riyanti, Puji Lestari, Toto Hadiarto, Reflinur, Joko Prasetyono, Fatimah, Surya Diantina, Tri Puji Priyatno, Kusumawaty Kusumanegara, Wening Enggarini, Rerenstradika Tizar Terryana and Dani Satyawan

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THE SECOND INTERNATIONAL CONFERENCE ON GENETIC RESOURCES AND BIOTECHNOLOGY: Harnessing Technology for Conservation and Sustainable Use of Genetic Resources for Food and Agriculture

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Preface: The Second International Conference on Genetic Resources and Biotechnology

The Second International Conference on Genetic Resources and Biotechnology, which is the continuation of the first event held in 2018, focuses on topics related to advances in biotechnology to create more opportunities for effective conservation and sustainable utilization of genetic resources for food and agriculture. This year conference's theme is Harnessing Technology for Conservation and Sustainable Use of Genetic Resources for Food and Agriculture. The conference was organized by Indonesian Agency for Agricultural Research and Development (IAARD), Ministry of Agriculture, Indonesia, in collaboration with Indonesian Biotechnology Consortium and held on 24^{th}-25^{th} of May 2021virtually due to the pandemic of COVID-19.

The conference aims to share and exchange current scientific information and technological developments on biotechnology and their applications for conservation and sustainable use of genetic, to encourage and promote quality, efficiency, and modernization of management and utilization of genetic resources, and to facilitate national and international collaboration among participants. There are five scopes discussed in this conference. They are effective management of conservation and sustainable use of genetic resources for food and agriculture, application of genomics and molecular markers for genetic resource conservation and crop adaptation to climate change, application of innovative crop improvement techniques for conservation and sustainable use of plant genetic resources for food and agriculture, plant cell and tissue culture for conservation and effective utilization of genetic resources, and the use of microbial genetic resources as biological control agents of agricultural pests and diseases, and for soil bioremediation.

Five speakers from the United States of America, Japan, India and Indonesia were invited to discuss about their expertise and knowledge on relevant subjects in the plenary sessions. This conference was attended by more than 100 participants including 75 presenters and 44 listeners worldwide. They came from diverse governmental, private, or academic institutions and also scientific communities. The presented materials have undergone peer review processes and only qualified papers were selected. Furthermore, all papers were subjected to double blind peer-review and expected to meet the scientific criteria of significance and academic excellence to be published in a conference proceedings indexed in a well-known, reputable service.

We would like to express our sincere gratitude to our speakers, presenters and all participants for their contributions in this conference. We would also like to express our appreciation for the generosity of our sponsors that support this conference: PT CropLife, PT ITS Science Indonesia, PT Fajar Mas Murni and PT Prima Instrument Analitika. Lastly, special thanks to all committee members for their exceptional work and contributions in the conference and publication.

Chair of Organizing Committee

Dr. Toto Hadiarto

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Lina Herlina and Yusi N. Andarini

Screening and Evaluation of 100 Upland Rice Accessions for Developing High-Yielding Upland Rice Varieties Tolerant against Acid Soil

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Abstract. Screening and evaluation of 100 upland rice accessions were carried out to investigate the traits that contribute to high yield. This study also aimed to provide information of rice germplasm, especially upland rice, which have high yield and tolerance against acid soils (aluminium toxicity) for further breeding purposed. The research was conducted at the Cikeumeuh Experimental Station, ICABIOGRAD, Bogor, West Java Province and Taman Bogo Experimental Station, Lampung, Lampung Province using a randomized block design with three replications. The results showed that the total spikelet number was among traits indicating high correlation and significant contribution to total sample weight. The accession with the highest total weight was Padi Plastik (21013), while the one with the highest total spikelet was Ketan Hitam (Jatim 6). The evaluation of resistance to acid land obtained five tolerant accessions, namely Rumbu A (20535), Kmadha Kedhi (20747), Segreng (Jateng 13), Local A (Jateng 14), and Marus A (Jateng 18). Clustering of 100 upland rice has grouped the accessions into three clusters where the Ketan Putih rice (Jatim 44) was the accession with the most different characteristics of flowering age and total spikelet than the others. The results of this study might be used as a reference for developing upland rice varieties with high yield potential and tolerance to acid soil.

INTRODUCTION

Stable supply and distribution of rice is confirmed to be a key factor for food security for the majority of the world's population. Meanwhile, rice supply is highly dependent on global rice production, which in this case is strongly influenced by the availability of production land. Population growth leading to intensification of food crop production, and market expansion leading to the commercialization of agricultural systems has prompted governments to implement policies and programs that affect the evolution of agricultural systems in the tropical highlands.

On the other hand, climate change is also a threat that needs special attention. Previous studies showed that increases in temperature, sea water, and changes in rainfall patterns and distribution that are thought to be a result of global climate change can lead to substantial modifications in land and water resources for rice production as well as the productivity of rice crops grown in different parts of the world. However, in the last few decades, due to the reasons for rapid population growth and followed by increased market demand for agricultural products, the government policy for land development for agricultural production has chosen the acid upland alternative as one of the focuses of a more intensive land use system, with strategies for better soil management practices [1].

Located in a tropical area, it causes Indonesia to experience a climate with high rainfall, thus leading to an intensive level of alkaline leaching within the soil, in order that the alkaline content is low, and therefore, the soil becomes acidic. Tropical and subtropical regions are reported to be areas where the soil acidification process occurs naturally and intensively [1]. Indonesia has a potential land area of 188.2 million ha, of which 148 million ha are dryland [2]. Related to this great potential, the government is now very aggressively making various new breakthroughs for the use of dry land as one of the bases for increasing production. In this regard, the contribution of

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upland rice become one of the prioritized targets. Upland rice which is usually grown on upland or on sloping land, especially in Southeast Asia countries, is grown aerobically with minimal input and is usually grown with low yields, as a subsistence crop in adverse upland conditions [3, 4]. Given the prediction of a global climate where many Asian countries will experience severe water problems by 2025, the aerobic rice from upland rice gives hope to farmers who do not have access to enough water to grow waterlogged lowland rice.

The contribution of upland rice production to the national production is reported very low, estimated only 5% [5]. The low productivity of rice in the highlands is caused by the use of local varieties which are generally deep (5–6 months) and low productivity [6]. Since now in Indonesia, there still very limited upland rice varieties which popular among farmers, therefore the government aggresively making efforts to release new varieties in order to provide the national needs of upland rice varieties. The most recent are included Inpago 13 Fortiz and Biobestari Agritan, which both are upland rice with high yield potential [7, 8].

Apart from being constrained by water availability, an important problem that must be faced by upland rice is the threat of soil acidity. The majority of acid highlands are occupied by Ultisols or red-yellow Podzolic soils, which are characterized by low available P content, low base saturation, low cation exchange capacity (CEC) values, and high Al, Fe, and Mn contents (potentially poison) [9]. Al toxicity is generally the main obstacle to increasing many crops production in the world [2], and also rice production in several new areas in Indonesia, especially in the highlands. Severe crop damage due to Al toxicity in upland acid soils contributes to the loss of the main yield of rice.

Various strategies have been carried out related to efforts to overcome Al toxicity in acidic soils, including liming, applying P fertilizer, and planting cultivars with low Al accumulation through genetic manipulation [2, 10]. However, continuous application of P fertilizer and lime in the soil is not only expensive but also has a risk to the environment, while on the other hand developing varieties with new properties may take 5–10 years, and the whole process involves a lot of time and money. Thus, efforts to identify the wealth of local rice germplasm to obtain genotypes that have tolerance to Al toxicity are expected to reduce the time duration (and costs) in achieving the assembly of these Al-tolerant varieties. Therefore, research opportunities related to increasing the productivity potential of upland rice through breeding for tolerant or tolerant variety against Al toxicity are very necessary. In order to support government programs to meet food security through increasing rice production, it is very important to conduct research to increase the tolerance of germplasm to Al toxicity. The objective of this research was to provide information of rice germplasm, especially upland rice which have high yield and tolerance against acid soils (aluminium toxicity) for further breeding purposed.

MATERIALS AND METHODS

The research was conducted during year 2014 to 2015 at the Cikeumeuh Experimental Station, Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development (ICABIOGRAD), Bogor, West Java Province for upland rice characterization, while the evaluation for tolerance ability against Al toxicity was conducted at Taman Bogo Experimental Station, Indonesian Soil Research Institute (ISRI), Lampung, Lampung Province.

The Characterization of Rice

The research were conducted in field using randomized block design with three replications. A total of 100 accesions of rice germplasm were characterized (Table 1). Plot size of 1 m × 3 m (4 rows), and spacing of 25 cm × 20 cm. The fertilizer 300 kg/ha urea, 100 kg/ha TSP, and 100 kg/ha KCl were given. The basal fertilizer are 1/3 urea, TSP, and KCl were given at planting time, and 1/3 dosage of urea fertilizer each were given at 4 and 7 weeks after planting (WAP). Observations on agronomic characters were conducted at the vegetative stage, the generative stage, and harvest, depend on the characters. The observations on the characters of growth and production supported were done based on the Standard Evaluation System (SES) for Rice [11], i.e. plant height (T), flowering age (UB), number of productive tillers (AP), number of total tillers (AT), and total spikelet number (TSN), which calculated from total grain number, and total sample weight (taken from panicles of a complete of 5 plants).

TABLE 1. List of 100 accessions of upland rice used in this research.

No.	Reg.	Accession	No.	Reg.	Accession	No.	Reg.	Accession
1	2071	Si Gambiri Bagal	34	20895	Pae Wila II	67	DIY 7	Pandan Wangi
2	5165	Balok Kura	35	20898	Pae Daye Ule-Ule	68	Jateng 12	Pudat a
3	5575	Bulan sabit	36	20898	Sawah Duku	69	Jateng 12	Pudat b
4	20389	Jala	37	20980	Padi Gogo	70	Jateng 12	Pudat c
5	20396	Ketan Babilem	38	21011	Jawa Wakai	71	Jateng 12	Pudat d
6	20535	Rumbu A	39	21013	Plastik	72	Jateng 13	Segreng1
7	20544	Semendang	40	21018	Padi Halus	73	Jateng 13	Segreng2
8	20545	Soder	41	21031	Ketalum Balo Putih	74	Jateng 14	Lokal A1 (round grain)
9	20577	Padi Ner	42	21093	Kalung Dayang	75	Jateng 14	Lokal B1 (long grain)
10	20717	Si Gambiri Etek	43	21385	Padai Pulut Pute Iting	76	Jateng 14	Lokal B2 (long grain)
11	20721	Mean Sukabi	44	21428	Padai Bala	77	Jateng 14	Lokal A2 (round grain)
12	20726	Iki Ola	45	21449	Padai Telangosan	78	Jateng 18	Marus A1
13	20727	Ekor Hitam	46	21451	Padai Ketan Hitam	79	Jateng 18	Marus B1
14	20728	Olan	47	21470	Padai Jata	80	Jateng 18	Marus A2
15	20730	Bibok I	48	Banten 12	Ketan Kasumba1	81	Jateng 19	Segreng3
16	20741	Padi Mufa	49	Banten 12	Ketan Kasumba2	82	Jateng 19	Segreng4
17	20745	Mamabhara	50	Banten 18	Ketan Hideung1	83	Jateng 5	Slegreng1
18	20747	Kmadha Kedhi	51	Banten 18	Ketan Hideung2	84	Jateng 5	Slegreng2
19	20749	Repong	52	Banten 22	Ketan Super	85	Jateng 6	Umbul-umbul1
20	20760	Rangkat B	53	Banten 23	Ketan Lason	86	Jateng 6	Umbul-umbul2
21	20767	Tepu	54	Banten 24	Ketan Hideung3	87	Jateng 7	Dodokan Abang1
22	20770	Nake Mita	55	Banten 24	Ketan Hideung4	88	Jateng 7	Dodokan Abang2
23	20791	Kemala Watar	56	Banten 29	Ketan Nagka1	89	Jateng 9	Ketan Salome1
24	20840	Padi Win	57	Banten 29	Ketan Nagka2	90	Jateng 9	Ketan Salome2
25	20841	Padi Areh	58	Banten 4	Cikapundeng1	91	Jatim 44	Ketan Putih1
26	20844	Superwin	59	Banten 4	Cikapundeng2	92	Jatim 44	Ketan Putih2
27	20845	Klara Super	60	DIY 11	Ketan Putih3	93	Jatim 6	Ketan Hitam1
28	20847	Pilihan Merah	61	DIY 11	Ketan Putih4	94	Jatim 6	Ketan Hitam2
29	20848	Ardas	62	DIY 12	Ketan Salome3	95	Si 1010	Ketan Wadas1
30	20850	Nurdin	63	DIY 12	Ketan Salome4	96	Si 1010	Ketan Wadas2
31	20853	Yenti	64	DIY 13	Ketan Serang1	97	Si 2320	Ketan Cikut1
32	20854	Apel Merah	65	DIY 13	Ketan Serang2	98	Si 2320	Ketan Cikut2
33	20890	Pae Daye Endolobye	66	DIY 7	Pandan Wangi	99	Si 3710	Ketan Lombok1
						100	Si 3710	Ketan Lombok2

Evaluation of Rice Germplasm to Al Toxicity

The evaluation was conducted on acid soil (pH ±4) using randomized blok design with three replications. About 100 accessions of rice germplasm were used with Singkarak variety as sensitive check and Hawara Bunar variety as tolerant check. The stripe check method was used by placing the control tolerant variety and the sensitive variety placed lengthwise and parallel to the varieties tested as much as 1–2 lines. Plot size of 1 m × 3 m (4 rows), and spacing of 25 cm × 20 cm. The fertilizer 300 kg/ha urea, 100 kg/ha TSP, and 100 kg/ha KCl were given. The basal fertilizer are 1/3 urea, TSP, and KCl will be given at planting time, and 1/3 dosage of urea fertilizer each was given at 4 and 7 WAP. Observations on tolerance to Al toxicity was conducted at the age of 4 and 8 WAP with the score using SES [11] (Table 2).

TABLE 2. Scoring for determining tolerance to Al toxicity [11].

Score	Level of tolerance	Symptom
1	Very tolerant	Normal/nearly normal growth of plant and tillers
3	Tolerant	Plant growth is almost normal but there are fewer tillers and plant leaves turn pale
5	Moderately tolerant	The growth of plants and tillers were reduced, most of the leaves turn pale, only a few plants grow elongated
7	Sensitive	Plant growth is completely stopped, most of the leaves dry up, some plants almost die
9	Very sensitive	Almost all plants are dead or very miserable

Data Analysis

Descriptive statistics, principal component analysis, Pearson correlation regression analysis, and clustering using average linkage using Euclidean distance were used to analyze the phenotypic data. Differences among the measured variables were considered as significantly different when the p-value was <0.001. The clustering using average linkage using Euclidean distance was also applied based on the level of similarity at 75%. All calculation and operation were conducted using the Minitab 19.

RESULTS AND DISCUSSIONS

Analysis of Quantitative Traits

Descriptive analysis of the agronomic characters recorded the highest and lowest values of the six variables tested, i.e. T, AT, PT, UB, TSN, and B (Table 3). The accession with the highest plant height was Lokal A2 (Jateng 14) with an average plant height of 197.67 cm, this accession was also the one with the lowest total tillers and productive tillers (having an average of 5 tillers) (Fig. 1). The accession with the lowest plant height was Padi Mufa (20741) with an average plant height of only 72.67 cm.

TABLE 3. Description of upland rice agronomic characteristics based on assay in the greenhouse.

Parameter	Plant height (T)	Total tiller (AT)	Productive tiller (PT)	Flowering age (UB)	Total spikelet number (TSN)	Total sample weight (B)
Minimum	72.67	5.00	5.00	86.00	50.67	1.00
Maximum	197.67	31.67	31.00	173.00	383.33	16.40
Mean	124.22	17.43	16.43	112.71	179.40	6.85
StDev	31.34	6.07	5.73	22.26	69.09	3.27
CoefVar	25.23	34.85	34.85	19.75	38.51	47.20
N	100	100	100	100	100	88
N*	0	0	0	0	0	12

The accession that had the most productive tillers was Ketan Hitam (Jatim 6) as well as the one with the most total tillers reaching an average of 31.67 tillers, and the highest number of spikelets with an average of 383.33 (Fig. 2). There were two accessions that had the fastest flowering age, namely Ketan Salome (DIY 12) and Segreng (Jateng 19) with an average flowering age of 86 days, while the longest flowering age was Kalung Dayang (21093) with 173 days. Accession with the highest sample yield weight was Padi Plastik (20728) with an average of total sample weight reach 16.40 g. Unfortunately there are 12 accessions for which data is missing for variable B, so that B is not included in the next analysis in clustering.

The results of the correlation analysis showed that there were fifteen pairwise combinations obtained from the six agronomic characters analyzed, four of which had a significant relationship at $p<0.01$. Of these, the highest correlation was observed between productive tillers (AP) and total tillers number (AT) with $r = 0.991$. Flowering age (UB) and TSN were variables that were not correlated with other variables. Likewise, the total sample weight (B) was also not correlated with any characters, except with TSN. The negative correlation indicated the opposite trend between both variables.

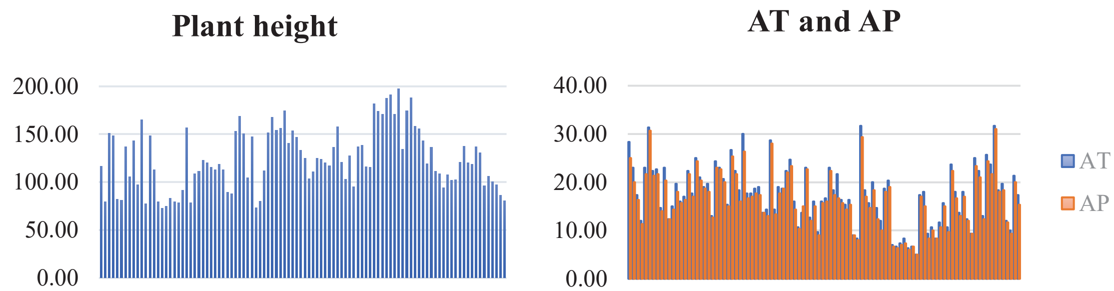

FIGURE 1. Plant height, productive tillering (AP) and total tillering (AT) of 100 accessions upland rice tested in this study.

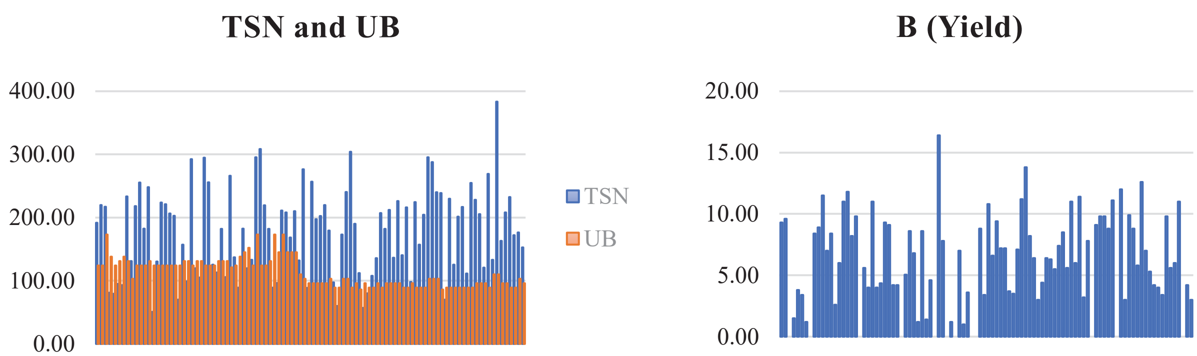

FIGURE 2. Total spikelet number (TSN), days of flowering (UB), and yield (Y) of 100 accessions of upland rice tested in this study.

Based on the analysis of the correlation coefficient with a p-value of 0.01, the correlation coefficient was obtained where all variables show a significant correlation, except for the flowering age (UB) and the total spikelet number (TSN). Thus, UB and TSN were orthogonal variables. Furthermore, these two variables were used as the basis for clustering.

Regression analysis to identify the contribution of the influence of each variable on the tested response (in this case the total sample weight) produced the following relationship model:

$$B=7.45 - 0.02505\ T - 0.1439\ AP - 0.0157\ UB + 0.03682\ TSN$$

According to this equation, the genetic improvement or an increase in the total spikelet number, which simultaneously accompanied by decrease in plant height, number of productive tillers, and flowering age would significantly increase the weight of the sample yield. The constant or intercept value of the regression model equation obtained was 7.45, indicated that to get a significant increase in yield, the total contribution of the variables in the regression equation must be at least greater than 7.45. The corrected coefficient of determination (Radjusted) of the regression equation was 67.50, which indicated that 67.50% of the diversity in the results obtained can be explained by the T, AP, UB, and TSN contained in the model. The remaining 32.50% was probably caused by other factors not included in the model.

Based on principal component analysis (PCA) of six agronomic characters of 100 upland rice accessions, there were two characters, AT and AP, which showed high PC-1 value of 0.607 and 0.608, respectively. TSN was the only character which had highest cumulative on PC-1 and PC-2, although only reach 66.9%. The analysis of eigenvalue of the proportion of cumulative diversity of each major component showed that the first three major componen were the main component explaining the largest data diversity, with cumulative eigenvalue of 88%.

From the previous result, it was known that UB and TSN were orthogonal variables, thus the two variables were used as the basis for grouping 100 rice accessions. In this case, the clustering was carried out using the average linkage using Euclidean distance method with a similarity limit of 75%.

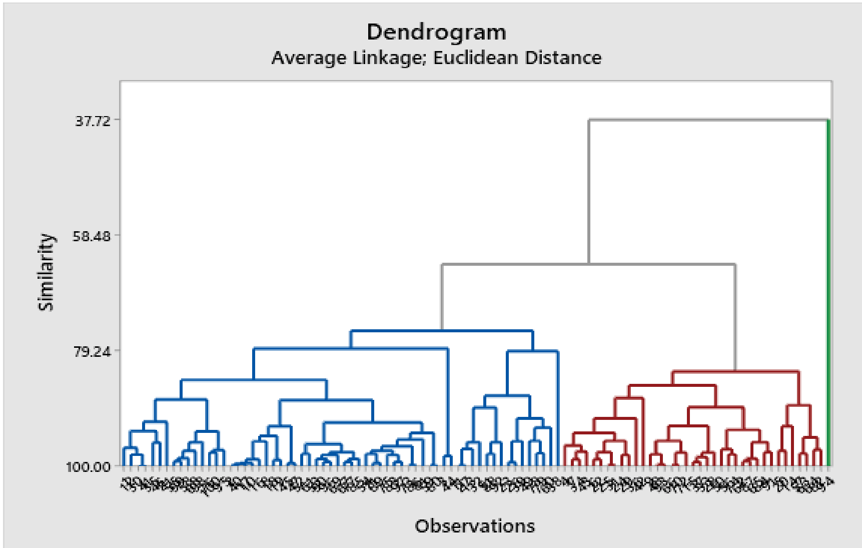

FIGURE 3. Clustering analysis of 100 accessions of uplad rice based on average linkage using Euclidean distance method.

The results of clustering based on average linkage using Euclidean distance with a similarity of 75% have grouped 100 observed upland rice accessions into three clusters (Fig. 3). The first cluster consisted of 62 accessions, the second cluster had 37 accessions, while the third cluster consisted of only one Ketan Putih accession (Jatim 44).

Evaluation of Tolerance to Al Toxicity

Upland rice accessions that are sensitive to Al toxicity, showing symptoms of yellowing at the tips of the leaves, also experience slow development (Fig. 4). The size of the plant becomes shorter, some accessions showed signs of twisted or budding leaves, while compared to Hawara Bunar as check for tolerant varieties, those accessions showed better development.

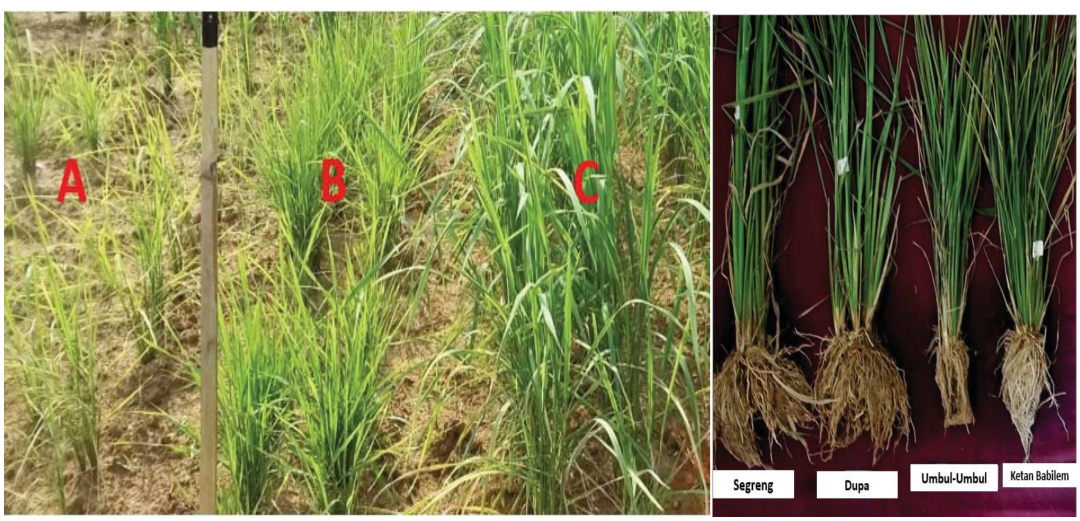

FIGURE 4. Rice growth in the field under Al stress (left) and root response of several upland rice accessions (right).

Based on the results of the scoring of plant tolerance to Al toxicity, there were five accessions that responded tolerant, namely Rumbu A, Kmadha Kedhi, Segreng (Jateng 13), Local A (Jateng 14), and Marus A (Jateng 18) (Table 10). Some of the accessions that responded were moderately tolerant, i.e. Bulan sabit, Soder, Padi Ner, Tepu, Padi Areh, Pae Wila II, Pae Daye Ule Ule, Sawah Duku, Superwin, Pilihan Merah, Ardas, Ketan super, Ketan Hideung, Ketan Putih, Pandan Wangi, Padi Pudat (three accessions), Segreng 2, Padi Lokal2, Ketan Salome1, Ketan Kasumba2, Kalung Dayang, Padai Pulut Pute Iting, Padai Telangosan, and Ketan Lombok1.

According to our study, the accession which had the most productive tillers was observed in Ketan Hitam (Jatim 6), which also had the highset total tillers and highest number of spikelet (Fig. 2). Rice tillers are branches that develop from the leaf axis on non-elongated basal joints, which grow independently of the parent stem [12]. Tillers are directly related to seed production in Gramineae because each tiller has the ability to produce panicles. The tillering capacity is a quantitative character, which is controlled by many genes [13] that is characterized by the continuous variation in distribution. The high number of tillers per plant is the most preferred character because it is associated with more panicle production [14]. This statement suggested that our study are relevance, which Ketan Hitam had high tiller and also high number of productive tillers.

Moreover, the number of high productive tillers is one of the important criteria for rice, both for varieties with high and low tiller capacity. Our result on correlation analysis showed that there is correlation between the number of total tiller with the number of productive tillers, which suggested that the higher the number of tillers, the higher the number of productive tillers. However, it is still within a certain limit in accordance with the capacity of plant growth/development because too many tillers are not good for plant growth [14–16]. Too many tillers trigger plant density, resulting in competition for light and nutrients. The possibility that what happens is that the percentage of tillers that cannot develop properly is also getting higher, or even many of the tillers die before producing panicles. An excessive number of tillers caused a high number of chicks to miscarry, the release of grain was not simultaneous, the size of the panicles was small, so that the grain yield was reduced [15]. It was also reported that the higher the number of tillers, the longer the tillers were, the more chicks did not develop or died before producing panicles [16]. As for the tillers that can produce panicles, the uneven maturity of the panicles will be affected so that the quality of grain produced at harvest is very low. In addition, tillers that do not produce panicles or are also called unproductive tillers, are productive tiller's competitors. It reduces the crop index of crops, and is not valuable agronomically and economically [14]. Several high yielding rice varieties released in Indonesia have a small number of tillers (less than ten), but these varieties have high productive tillers [14].

According to our study, the contribution of total spikelet number would increase the yield, as presented in regression analysis. This suggested that total spikelet number play important role for yield component. As previously mentioned, the calculation of the total spikelet number in this study uses the total grain number calculation approach. Thus, the literacy associated with the study of the total grain number also applies to the total spikelet number in this study. Related to this, the grain number per panicle was confirmed as the main components of rice yield grain [17]. Thus, it is appropriate to suggest that the total spikelet number (or total grain number) is a very important yield component.

The percentage of acid soils that reach the proportion of 35 to 50% of arable land, is a threat to crop productivity [1, 18]. Many studies have reported on the adverse effects of Al toxicity on plant growth and development [1, 19, 20]. In principle, soil acidification by Al is the replacement of important alkaline ions (Mg, K, and Cl) by acid ions (Al and H) [1], which results in disruption of root development, root hair lengthening, nutrient absorption, and nutrition, disrupts the cytoskeleton, disrupts apoplastic processes, induces oxidative stress, and interferes with intracellular transport [1, 21, 22].

Our study showed that the response of upland rice accessions tested to Al toxicity varied, but majority of upland rice accessions were sensitive to Al toxicity. This is in accordance with reported by Rahman *et al*. [1] that the responses of plants to Al toxicity can vary among the different genotypes of the same species, or even across different species. Of the 100 accessions tested, only 5 accessions responded tolerant to Al toxicity. However, 27% of accessions responded moderately tolerant, and this is good prospect. Symptoms shown by plants with Al poisoning include stunted growth, which is indicated by the appearance of plants that look more stunted or abnormal growth (Fig. 4). Roots in tolerant accessions showed significantly difference from those of sensitive accessions. In the sensitive accessions, the roots were shorter or abnormal, and not as many as the roots in tolerant accessions. The significant effect of Al toxicity in the inhibition of plant rooting is in accordance with as reported by Tyagi *et al*. [23], who stated that different tolerances to Al toxicity were associated with variations in root structure and function. Brief exposure to low Al concentrations can only inhibit cell elongation. However, continuous exposure to high Al concentrations inhibits cell elongation and division and causes abnormal root morphology [23]. It was further reported that among small grained cereals, rice was the most tolerant of cereals, whereas the *japonica* varieties were more tolerant than the *indica* varieties. Al toxicity tolerance in rice is a multigenic trait that has complex genetics which is supported by the identification of 32 QTL loci [23].

CONCLUSION

Evaluation of the yield components of 100 local rice accessions showed that the total spikelet number was the variable with the most significant contribution to yields. Accession with the highest total weight was Padi Plastik (21013), while the one with the highest total spikelet was Ketan Hitam (Jatim 6). Clustering of 100 upland rice has grouped accessions into three clusters, where the Ketan Putih rice (Jatim 44) is the accession with the most different characteristics of flowering age and total spikelet than the others.

The evaluation of resistance to acid land resulted in five tolerant accessions, namely Rumbu A (20535), Kmadha Kedhi (20747), Segreng (Jateng 13), Local A (Jateng 14), and Marus A (Jateng 18). Rice plants showed a response to inhibition of growth and development when exposed to Al toxicity, in the significant form of abnormal growth and appearance. In addition, the plant rooting also becomes very undeveloped (short and abnormal).

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