Selection of Acehnese germplasm of rice (*Oryza sativa* L.) using SRI approach in the post-tsunami affected area of Aceh Province, Indonesia

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Abstract. After affected by the giant tsunami waves following the 9.1 earthquake on December 26, 2004 in Aceh province of Indonesia, many of natural resources were damaged, including the loss of germplasm of rice in low land area. Therefore, we attempt to collect and evaluate the Acehnese germplasm of rice. We identified the Acehnese accession of rice by describing the characteristics of the rice plant using cultivation method of system for rice intensification or SRI with organic approach. Some of the descriptors include days of tillage formation, days from emergence to flowering, kernel weight, plant height, and yield components. We found that the Acehnese rice germplasm collection is very diverse: the days of tillage formation is 6 to 18 days after planting; the days from emergence to flowering is 56 to 90 days, plant height is 77 to 121 cm, and 1,000 kernel weight is 19.47 to 30.27 g. So, we concluded that the diversity of Acehnese rice is very rich, the rice accessions were identified and now stored in the cool storage system. Evaluation of the accession showed considerable promise as material research with high yield potential, high levels of tolerance to stresses such as weeds, drought, acidity and blast for further evaluation. The progenies might provide the improved sustainability of intensified systems through durable crop resistance to biotic and abiotic stress. In the future, characterization traits will be selected for resistance to pests-diseases, and tolerance to drought and salinity stresses, as well as analysis of grain quality. We will also develop the high multiple resistance to environmental stresses.
Keywords: selection, germplasm, rice, tsunami, Aceh

Introduction

The natural disaster of the giant tsunami waves following the 9.1 earthquake on December 26, 2004 in Aceh province of Indonesia caused seriously damages of natural resources, including the loss of germplasm of rice in low land area, soil salinization of agricultural lands and cracked to irrigation and drainage channels of paddy rice field. Whereas, the germplasm of rice is very important to develop new variety in future. Therefore, collection and conservation of germplasm must be attempted to ensure the availability of plant genetic material for plant breeding. Improvement of plant characters to increased productivity is one of priority work in plant breeding recently, especially characters rising environmental stresses. Thereby, we should collect and evaluate the existing plant materials. Germplasm characterization is an important operation for a gene bank. The value of the germplasm collection depends upon the availability of information relative to the accessions. Morphological and agronomic traits as well as reaction to biotic and abiotic stresses that are known to be in the individual accessions increase the importance of the germplasm. Moreover, systematic description leads to a more efficient use of germplasm in the collection. Thus, this research effort to evaluate and select the Acehnese germplasm of rice for further study.

In other side, the province of Aceh also has an issue about global warming. Sipayung (2007) analyzed that the daily temperature has been increase as the highest point in Aceh, one of the province of Indonesia, located on the northwestern tip of the island of Sumatera. The temperature change in Aceh shows the surface temperature increase of about 1.9ºC (CGCM) and 2.1ºC (CSIRO) during period of a hundred years (1900-2000) observations. High temperature is becoming one of the significant abiotic stresses limiting plant growth and productivity, especially as the global temperature is probable to increase by 1.8°C–4.0°C at the end of 21st century (IPCC, 2007). Additionally, Sipayung (2007) analyzed that the temperature change in Aceh shows the surface temperature increase of about 1.9ºC (CGCM) and 2.1ºC (CSIRO) during period of a hundred years (1900-2000) observations. High temperature is becoming one of the significant abiotic stresses limiting plant growth and productivity, especially as the global temperature is probable to increase by 1.8°C–4.0°C at the end of 21st century (IPCC, 2007). Therefore, the impacts of global warming and the loss of germplasm due to the tsunami wave in this province become more serious problem for insuring food security in the future.

Adaptation and mitigation for the disaster and climate change should be raised to create more resilient approach to anticipate food crisis. The system of rice intensification (SRI) around the world will be an innovation in many processes can raise the productivity of the land, labor, water, and capital in rice production (Efendi, 2011). There are costs involved with SRI adoption, particularly increased labor from farmers during their beginning education phase. Furthermore, with skill and belief, SRI can become labor-saving over time, saving water and seed, reducing costs, and raising paddy output (Uphoff, 2008)

The method of SRI enhance the growth and functioning of rice plants, root systems, and elaborate the numbers and diversity of the soil organism that serves to plant health and productivity (Uphoff, 2003; Randriamiharisoa *et al*., 2006). The method of SRI is raising not only the yield of paddy without anticipating on improved varieties or agrochemical inputs, but also to increase the outturn of milled rice (Uphoff, 2008). Rice plant produced by SRI method enhances performances both quantity and quality. Many farmers report and researchers have validated that SRI crops are more resistant to most pests and diseases, and better capable to tolerate adverse climatic affects. Resistance to biotic and abiotic stresses will become more important in the coming decades as farmers around the world have to cope with the effects of climate change and the growing frequency of extreme events (Uphoff, 2007). It is continuously being adapted for diverse environments as these environments and SRI becomes well understood.

In this research, we attempted to select some characters of Acehnese germplasm of rice using SRI approach in the Post-Tsunami affected Area of Aceh province, Indonesia. The selected material will be used as a material in further studying somaclonal variation of embryogenic callus for *in vitro* selection and regeneration of plantlets that are tolerant to drought and salinity stresses.

Materials and Methods

Analysis of seed accession

Rice germplasm research conducted at Laboratory of Seed Science and Technology, Faculty of Agriculture. We emphasized two approaches: (1) characterization and (2) evaluation of morpho-agronomics. Characterization of seed performances and phenotypic plant of each accession described and catalogued for identifying the accession traits. In addition, genotypic differences and similarities also are characterized and catalogued. These data along with the evaluation for each accession served as the database in developing strategies for a core collection of rice germplasm. Evaluation of laboratory and field evaluation experiments for useful characters are conducted in experimental farm. Emphasis will be on evaluating for SRI responds with organic approach of cultivation. Thirty genotypes of rice containing approved varieties and elite candidate lines of different research organizations were included in this experiment.

Cultivation of the rice accession

The cultivation of field experiment was conducted with the method of SRI in the district of Aceh Besar, province of Aceh, Indonesia that severe affected by giant tsunami on December 26, 2004. The climate of the district is type C with 26-36°C of minimum and maximum temperature, and 75-90% of humidity. The local Acehnese varieties of rice were focused as the target of this research to collect and to identify the germplasm of rice in the Post-tsunami affected Area of Aceh, Indonesia. The rice seeds were germinated and sown into a tray containing natural sandy loam soil with 20% of compost. Then seven days old seedlings were transplanted into each pot filled with 3 kg of soil containing 5:1 of sandy loam and compost. For basal dressing, nutrient was applied for each pot with 50 g of organic fertilizer (cow manure) at ten days before transplanting. The top dressing was applied at 30 days after transplanting by using organic fertilizer (Petroganic 50 g1 pot).

Evaluation of morpho-agronomics

Some morphological characteristics i.e., days to tillage formation, days to flower, plant height, number of tillers, and 1000-grains weight were recorded on plant and pot basis and the data thus collected were subjected to analysis using descriptive methods. The Acehnese and national varieties used in this research are: *Arias, Pandrah, Asahan, Pandan Wangi, Beras Merah, Pade Mas, Bestari, Pade Mirah, Bo 100, Pade Pangku, Bo Santeut, Ramos 4 Bulan, Cut Krusek, Rom Ilang, Dupa, Sanbei, Kencana Bali, Tawoti, Limboto, and Vari.*

Results and Discussion

The analysis of variance for means indicated that the differences among the genotypes were significant for the Acehnese accession of rice (Table 1). In this study, we found the significant results of days to tillage formation, numbers of tillage, plant height, days to flowering, and weight of 1000 grain for 20 genotypes of rice germplasm collection. Kotaiah *et al*. (1986) and Bharadwaj *et al*. (2001) reported that the significant differences among the rice genotypes indicated the necessity to group them into clusters to identify the divergent groups.

Tabel 1. Morphological characteristics for days to tillage formation, number of tillers, and plant height for 20 genotypes of Acehnese rice accession

Accessions of Rice	Days to Tillage Formation	Numbers of Tillage		Plant Height (cm)	
		30 days after Planting	60 days after Planting	30 days after Planting	60 days after Planting
Arias	13	2.7	4.0	68	113
Asahan	9	6.7	8.0	47	83
Beras Merah	10	3.3	9.0	44	86
Bestari	9	7.0	17.0	49	77
Bo 100	9	5.0	15.0	50	96
Bo Santeut	13	6.7	17.0	51	82
Cut Krusek	12	6.0	18.0	58	103
Dupa	15	2.0	8.0	68	115
Kencana	10	3.0	10.0	63	117
Limboto	13	2.3	5.0	55	113
Pandrah	9	6.0	20.0	55	95
Pandan Wangi	10	5.7	13.0	56	113
Pade Mas	9	4.7	14.0	54	99
Pade Mirah	18	4.3	16.0	44	77
Pade Pangku	14	2.3	5.7	61	118
Ramos	6	8.3	8.7	52	83
Rom Ilang	10	3.3	10.3	68	121
Sanbei	8	6.3	17.3	50	93
Tawoti	8	7.3	15.7	43	80
Vari	10	2.0	5.3	64	117

Days to Tillage Formation and Numbers of Tillage

Observation of tillage formation (Table 1) showed that the Acehnese accession of rice have a range 6-18 days to tillage formation after planting. Accession of *Ramos* has the shortest time to form their tillages. While, the longest period for tillage formation occur on *Pade Mirah* accession, 18 days after planting. The results of study showed a phenotypic variation in days to tillage formation as plant responses in the method of SRI. Nemoto *et al*. (1995) explained that although primordia for tillers always are initiated by the plant, they do not always develop or may show delayed development. Some varieties develop their tillage in short time and the others longer. Active tillering at *Ramos* accession refers to the growth period when tillers emerge in rapid succession.

The results of this study (Tabel 1) showed that the number of tillages at 30 days after planting indicated a high genetic variation in Acehnese rice accession as their respond to the cultivation method of SRI. We found that the *Ramos* accession has the highest numbers of tillage at 30 days after planting. However, the results of observed plants in field showed that variety of *Pandrah* had the highest numbers of tiller at 6o days after planting. Whereas, the numbers of tiller of *Ramos* is commonly lower than others varieties. Smith and Dilday (2008) explained that some cultivars have a maximum tiller number and are also observed to have a termination point for effective tillering. This condition of tiller number relates to the number of panicles at maturity. The tillers produced after this stage does not form panicles.

Additionally, this study (Table 1) indicate that the observed accession also vary in tiller number as well as in earliness and vigor of tillering (Figure 1). Yoshida (1981) revealed that some cultivars very form tillers early; others show delayed or sparse tillering. The formation of tiller also is affected by plant spacing and soil fertility. When we plant seed in low densities, tiller numbers increase and the duration of tillering is extended. Performances of tillering are important to rice productivity because they affect the number of culms per square meter, the uniformity of ripening in the field, and grain yields per panicle (Jennings *et al*., 1989). So, moderate numbers of vigorous early tillers are considered the most advantageous to produce a maximum yield (Counce *et al*., 1996).

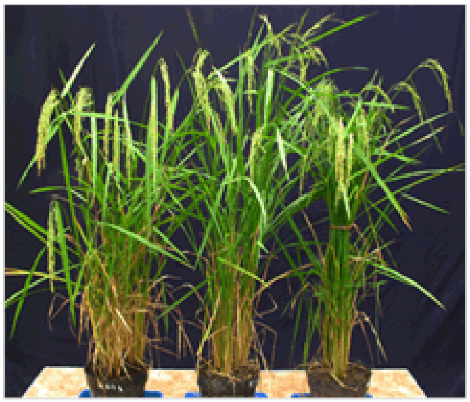

Figure 1. The accession of Acehnese rice showed vary in tiller number as well as in earliness and vigor of tillering

Plant Height

According to plant growth observation in field (Table 1) showed that variety of *Rom Ilang and Dupa* had the highest plant at 30 days after planting with height of plant 68 cm. While, variety of *Tawoti* had the lowest plant height at 30 days after planting with the plant height 43 cm. The other varieties showed significantly different in plant height. This results indicated that the Acehnese accession of rice have high genetic variation (Figure 2).

Smith and Dilday (2003) explained that the plant height is affected by a series of nodes and internodes. Internode elongation during vegetative growth is generally the culm remains close to the ground and less develop. However, during reproductive growth, the uppermost internodes elongate to exsert the panicle above the leaf sheaths. Continuously, Hoshikawa (1989) revealed that the cotyledonary node, at the culm base, is morphologically unique. The total number of nodes on the main culm of the rice plant relates to the number of leaves. Culm height can be measured to either the base or tip of the panicle. It is a measurement of overall plant height. The results of the accession evaluation showed considerable promise as material research with various good characters, for example high yield potential, high levels of tolerance to stresses such as weeds, drought, acidity and blast for further evaluation. The progenies might provide the improved sustainability of intensified systems through durable crop resistance to biotic and abiotic stress.

Figure 2. One of Acehnese accession of rice has high genetic variation especially in plant height

Days to Flowering

Results of this study showed a phenotypic variation in days to flowering as plant responses to SRI method of cultivation. We found that the days to flowering of all accession formed flower in different period (from 57.7 to 90.3 days). The shortest period of flowering found at Limboto variety. Meanwhile, the *Cut Krusek* of local Acehnese accession produced flower at the longest period for flowering or heading. The others varieties also showed significantly different in days to flowering (Table 2). The days to flowering related to panicle initiation during reproductive growth of rice plant. Blanco (1982) revealed that panicle initiation marks the onset of the reproductive phase and begins with the first differentiation of bract primordia at the shoot apex. In some cultivars, panicle initiation can occur only 15 days before heading. Additionally, Moldenhauer *et al*. (1994) explained that the first visible sign that it has taken place is referred to as the *green ring stage*, at which point a thin green band is briefly visible at the lowermost internode prior to its elongation. During this period, environmental factors such as temperature extremes, drought, nutrient efficiencies, or toxicities can reduce numbers of panicle branches and/or spikelets and reduce pollen viability. This affects directly the second and third yield components (Smith and Dilday, 2003).

Tabel 2. Reproductive characteristics for days to flowering and Weight 1000 Grains for 20 genotypes of Acehnese rice accession.

Accessions of Rice	Days to Flowering	1000-Grains Weight (g)
Arias	84.3	21,60
Asahan	68.0	21,87
Beras Merah	72.7	26,40
Bestari	73.0	27,60
Bo 100	86.3	19,47
Bo Santeut	86.3	22,67
Cut Krusek	90.3	20,27
Dupa	79.3	30,00
Kencana	75.3	28,13
Limboto	57.7	28,40
Pandrah	72.0	28,00
Pandan Wangi	58.7	27,87
Pade Mas	77.0	30,20
Pade Mirah	72.3	19,60
Pade Pangku	86.7	28,00
Ramos	76.7	24,80
Rom Ilang	74.0	30,27
Sanbei	72.3	23,87
Tawoti	66.0	28,00
Vari	79.3	30,00

1000-Grains Weight

According to the measurement of grains weight, the results showed a phenotype variation in grains size and others performance of Acehnese rice accession (Figure 3) by way of plant responses to the system of rice intensification (SRI). In previous study, we stated that the SRI technology can improves the growth and functioning of rice plants root systems and enhances the numbers and diversity of the soil biota. SRI also report a reduction in pests, diseases, grain shattering, unfilled grains and lodging, as same as the reduction of agricultural chemicals, water use and methane emissions of global warming. The SRI method reduces the agronomic and economic risks that farmers face (Efendi, 2011). Furthermore, we found that 1000-grains weight (Tabel 2) of Acehnese rice was significantly different among the accession. The smallest size of grains found at accession of *Bo 100* (19.7 g^{-}1000 grains). Whereas, the *Rom Ilang* accession showed the biggest size of grains (30.27 g^{-}1000 grains). We assumed that the grains size is also affected by ripening process during reproductive phase. Yoshida (1981) stated that grain growth during ripening is characterized by increase in size and weight of kernels as starch and sugars are translocated from culms and leaves. Sarwar *et al*.(1998) found that there were significantly different regarding values of morphological characters of rice grains. Grain size is the most important factors which influence yield a quality of rice. The grain had a strong correlation with 1000-grain weight.

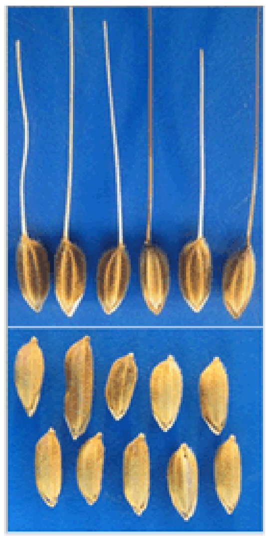

Figure 3. Performances of phenotype variation of Acehnese rice accession

Conclusions

We concluded that the diversity of Acehnese rice is very rich. The Acehnese accession of rice showed a phenotypic variation in days to tillage formation as plant responses in the method of SRI. The number of tillages at 30 and 60 days after planting indicated a high genetic variation in morphological characters. Results of this study also showed a phenotypic variation in days to flowering as plant responses to SRI method of cultivation. We found that the days to flowering of all accession formed flower in different period. We also successful to identify high genotype performances in grains size by way of plant responses to the system of rice intensification. The identified accession might provide the improved sustainability of intensified systems through durable crop resistance to biotic and abiotic stress. In the future, characterization traits will be selected for resistance to pests-diseases, and tolerance to drought and salinity stresses, as well as analysis of grain quality.

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