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REVIEW

The use of Biotechnology in the Characterization, Evaluation, and Utilization of Indonesian Rice Germplasm

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ABSTRAK

Penggunaan Bioteknologi dalam Karakterisasi, Evaluasi, dan Pemanfaatan Plasma Nutfah Padi Indonesia. *Tiur S. Silitonga.* Beras merupakan makanan pokok penduduk Indonesia yang terus meningkat kebutuhannya. Untuk memenuhi kebutuhan beras nasional, peningkatan produktivitas varietas padi terus diupayakan melalui peningkatan potensi hasil dengan cara merakit varietas tipe baru dan padi hibrida yang berdaya hasil tinggi dan genjah, tahan terhadap cekaman biotik dan abiotik. Sejak tahun 2006 sampai saat ini jumlah varietas yang dihasilkan sebanyak 31 varietas. Perakitan varietas itu semua dilakukan dengan menggunakan plasma nutfah. Sampai saat ini plasma nutfah yang dilestarikan di Bank Gen Balai Besar Penelitian dan Pengembangan Bioteknologi dan Sumberdaya Genetik Pertanian (BB-Biogen) berjumlah sekitar 4.000 aksesi yang terdiri atas varietas padi lokal, varietas padi unggul lama, varietas unggul tipe baru, galur-galur elit, dan kerabat spesies padi liar. Untuk menjaga keselamatan koleksi, sebanyak 2.500 aksesi dilestarikan di Balai Besar Penelitian Padi sebagai koleksi duplikat. Di samping itu, sebagai mitra kerja sama internasional, koleksi ini juga disimpan di pusat pelestarian plasma nutfah padi *International Rice Research Institute* (IRRI) sebanyak lebih dari 8.900 aksesi. Plasma nutfah ini memiliki peranan yang sangat besar sebagai sumber gen dalam program pemuliaan padi. Untuk mempermudah pemanfaatannya, koleksi ini telah di karakterisasi, dievaluasi, dan didokumentasikan di dalam database. Karena plasma nutfah memiliki nilai potensial dan nilai aktual bagi kehidupan manusia, maka sangat penting untuk melestarikannya baik secara *in situ*, *ex situ,* dan lekat lahan (*on farm*). Pada tulisan ini diuraikan status koleksi plasma nutfah, bagaimana dikoleksi, karakterisasi, evaluasi, dan didokumentasikan dalam database dan dimanfaatkan dalam program pemuliaan padi serta dalam pertukaran plasma nutfah padi. Dalam pemanfaatan dan pertukaran plasma nutfah, Indonesia telah meratifikasi perjanjian pertukaran sumber daya genetik dan mengimplementasikannya dengan menggunakan *Standard Material Transfer Agreement* (sMTA) melalui UU No. 4 Tahun 2006.

Kata kunci: Plasma nutfah, padi, bioteknologi.

INTRODUCTION

Traditional varieties and the wild species of rice are being lost through genetic erosion. Farmers adopt new varieties, and cease growing the varieties that they have grown for generations. The wild rice species are threatened as their habitats are destroyed by human disturbance. Rice crop improvement needs genetic resources from the traditional varieties and related wild rice species to cope with the many biotic and abiotic stresses that challenge rice production in Indonesia.

In Indonesia, the traditional rices and their wild relatives of rice have been collected through exploration and collection missions. More than 4.000 rice accs. comprise of landraces, high yielding varieties, elite lines, introduced varieties or lines, and wild rice species are currently stored in the Genebank in Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development (ICABIOGRAD), Bogor, Indonesia. About 2.500 accessions of the collection are kept as duplicate samples as working collection in Indonesian Institute for Rice Research (IIRR), Sukamandi, West Java, and more than 8.500 accessions are stored at the International Rice Research Institute (IRRI), Los Banos, Philippines. The genebank has the facilities for active collection and base collection. These germplasm have been characterized, evaluated, and documented in the database to make easier to access, and utilize them. The germplasm of rice have been used as gene resources in the breeding program to increase the productivity of the rice crop.

This paper is a review on the use of biotechnology in the characterization, evaluation, and utilization of Indonesian rice germplasm. The documentation, as and information exchange of the rice germplasm are also describe. It is hoped that those rice germplasm which have potential value be effectively and efficiently used for rice improvement and can create many high yielding varieties adapted to specific location, resistant or tolerant to biotic and abiotic stresses. Therefore, the farmers can decide which variety that can be grown in their land. Farmers food security depend upon continued access to high yielding varieties developed from the breeding program. Sustainable food security could be strengthen through creating various better high yielding varieties by using various of rice germplasm with wide genetic variability as parents.

CONSERVATION OF RICE GERMPLASM

Plant conservation is the management of plant resources to maintain current level of plant diversity and to avoid population and taxonomic extinctions (Maunder 2001). In this content referring to conservation of rice germplasm. Many of the domesticated rice varieties cultivated in the existing agro-ecosystems are generated from local resources. These varieties highly contribute to the increase in rice productivity. They also contribute to food security in the villages because they have specific traits that enable them to grow well and have optimum production in those ecosystem. Therefore, it is important to keep the communities interest in conserving and maintaining local rice in their land as *in situ* or *on farm.* The collected samples are conserved *ex situ* in the genebanks of ICABIOGRAD and in IIRR that participate in germplasm conservation as working collection and utilization. More than 4.000 accessions of rice germplasm that consisting of landraces, elite lines, high yielding varieties, introduced variety/lines as well as 88 accessions of wild rice species are holding in ICABIOGRAD. Beside those collections, biotechnology products such as rice transgenic lines, anther culture lines, mutant, and somaclonal variations are also can served in separated genebank, in Biomolecular Divisions of ICABIOGRAD. Among of the collections, the largest number is from West Java (645 accs.), consisting of local varieties, modern, and elite lines. East Kalimantan (386 accs.), East Java (342 accs.), West Kalimantan (276 accs.), and Nanggroe Aceh Darussalam (225 accs.) while the rest were from other provinces in Indonesia. About 2.500 duplicates of the samples are kept in the IIRR as a working collections and also more than 8.900 accessions at the IRRI Los Banos, Philippines. The Indonesian rice germplasms which were at the IRRI were the results from joint collection misssion with IRRI which were conducted from 1972 to 1999.

Seeds of each accessions were stored in the Genebank under conditions that will maintain their viabilities for long periods. As a base collection, the seeds were stored for long term storage at -18°C. For an active collection, the seeds were stored 0 ± 2°C for medium term storage, while for short term period, the seeds were stored at 15°C. During the storage, the seeds are monitoring for their viability. Seed viability is the most important aspect of seed quality. It is a measure of how many seeds are alive and capable of growing into normal plant. The viability is determined before the seeds are packed and placed in the storage and tested at a regular intervals during storage. This viability is usually expressed in percentage of seed germination and it will be used as a guide in the regeneration process of an accession. Initial germination results the storage potential of the seed in a certain condition. Only seeds of high quality and high viability (>90% for indica and *O. glaberrima*, and >85% for japonica materials) are processed and packed for long term conservation.

Monitoring of seed viability is necessary to determine whether or not the germplasm need to regenerate or rejuvenate. Besides, seed availability or weight of the seeds should be monitored each time seeds are removed from the storage for whatever purpose. When an accession is less than 60 g in the active collection, it should be regenerated. This is conducted base on manual operations and procedures of the International Rice Genebank (IRRI 1995).

To promote plant genetic resources conservation, the National Committee on Genetic Resources has developed 19 Regional Committees on Genetic Resources in 18 provinces located in South Sumatra, Lampung, Jambi, Riau, West Sumatra, North Sumatra, and in Java (Province of Banten, Yogyakarta, Central, and East Java) and two district level: (Tasikmalaya City and Tasikmalaya Distric), in Kalimantan are West, Central, East, and South Kalimantan provinces, South Sulawesi, and South East Sulawesi Province and regional committee in Bali. The other 15 provinces are in the process on establishing the regional committee. All of these committees are under the respective local government. Mulawarman University as one of the member in regional commette in East Kalimantan has conserved more than 400 accession of local rice. SPTN-HPS (NGO) in Yogyakarta also conserve about 70 rice germplasm.

EXPLORATION AND COLLECTING OF RICE GERMPLASM

Rice germplasm collecting has been colaborative activity as a national program between ICABIOGRAD and Agriculture Extenstion Office, Assesment Institute for Food Crops, as well as other stakeholders, such as NGOs: SPTN-HPS in Yogyakarta and Rice Foundation in East Kalimantan, Agriculture University (UGM) in Yogyakarta and Mulawarman University in East

Kalimantan and also with the international collaboration, such as IRRI, Office de la Recherche Scientifique et Technique de Outre-Mer (ORSTOM), Swiss Development Cooperation (SDC), and Cornell University (USA). Collaboration with IRRI has been conducted from 1972 to 1999. The collecting mission were intensively conducted between 1995-1999 through a joint cooperation with SDC Project. Many local rice varieties were collected almost from all provinces in Indonesia. However, it is still needed to have collection in the remote areas such as in a swampy areas or in the forest for wild rice species. In 1999, a collection mission from ORSTOM in collaboration with an NGO-Rice Foundation collecting local and wild rice species from East Kalimantan. A number of 170 local rice varieties were collected. A collection team from the IRRI-SDC Project found two wild rice species, *O. meyeriana* and *O. officinalis,* from Central Sulawesi, and four other species, *O. officinalis, O. meridionalis, O. longiglumis*, and *O. rufipogon* from Merauke, Papua (Silitonga 2002). Vaughan (1994) mentioned that *O. meridionalis* that was found in Australia also found in the Wasur National Park, Merauke, Papua (Lu and Silitonga 1999). In a collaboration with the Cornell University, USA, a number of 183 rice varieties had been collected from 18 villages of remote areas along the Bahau and Kayan rivers in East Kalimantan. There varieties had been used for SSR genotyping (Thomson *et al*. 2009). Another 168 rice germplasm have also been collected during the exploration conducted in 2008. The newly collected seeds have been tested their viability, but 68 of the germplasm were not viable and only 100 germplasm have been rejuvenated after then.

REJUVENATION OF RICE GERMPLASM

Rejuvenation or regeneration is the seed increase of germplasm materials that have low viability during routine monitoring after a period of storage and accessions with insufficient stock for either distribution or for long term conservation. One of the major activities in the genebank is the production of high quality seeds for long term conservation. The need to preserved the genetic structure of an original sample or new collected seeds should be considered in determining the frequency of generations. The initial seed increase includes all new material that need seed multiplication for the first time, and all materials planted previously due to low viability, seed insufficiency or seed contamination. It is ideal to produce them with the least number of rejuvenation or regeneration cycles, because it prevents from or minimizes losses of unadapted or susceptible rice germplasm. Regeneration was usually conducted in the field. However, it has been conducted in rice anther culture (Dewi *et al*. 2004; 2006), and in soybean (Abdullah *et al*. 1997).

Since 2008 to 2010, ICABIOGRAD has been collaborating with the Global Crop Diversity Trust (GCDT) on regeneration of rice germplasm. During the this collaboration, 600 rice accessions have been regenerated, and 300 more accessions are being regenerated at the IIRR, Sukamandi. All the regenerated germplasm will be stored in duplicate at IRRI and in Svalbard by using the sMTA. In the future, it is needed to consider the use of in vitro culture or microbe to rejuvenate rice germplasm that difficult to germinate.

CHARACTERIZATION AND EVALUATION OF RICE GERMPLASM

The rice germplasm collection have been characterized their 44 morphological and agronomic characters and evaluated based on the Standard Evaluation System for Rice (IRRI 1996). Data on result of the characterization and evaluation are shown in Table 1. Results from characterizations of rice germplasm for important morphological and agronomic traits within *O. sativa* as well as within the wild rice species showed very wide variations (Silitonga *et al.* 2001, Suhartini *et al*. 2003). Plant heights of the rice germplasm ranged from 57 to 161 cm, the plant growth periods ranged from 85 to 180 days. Several accessions of the wild rice species also showed variations in their plant heights, flowering times, number of filled grains, and the weights of 1.000 seeds. *O. alta* had number of filled grains ranged from 370 to 470 seeds, while in *O. latifolia* ranged from 270 to 490 seeds.

Characterization and identification using molecular techniques had also applied to analyze genetic diversities of the germplasms. Septiningsih *et al.* (2004) analyzed on 96 rice accessions (Table 2) using the Simple Sequence Repeat (SSR) markers and resulted in 4 to22 alleles for each primers. Thomson *et al.* (2007) also characterized 330 rice accessions consisting of 246 landraces, 63 improved cultivars, 18 international varieties as controls, and three accessions of *O. rufipogon*. The 246 rice landraces represented the broad geographic range of rice cultivation across 21 provinces of Indonesia (Table 3). It was indicated that a total of 394 alleles were detected at the 30 SSR loci with an average 13 alleles per locus among the accessions, and with an average value of polymorphism information content 0.66. Results of the genetic diversity analysis indicated that

Table 1. Characterized and evaluated rice germplasm that can be used as sources of genes in the breeding program.

Rice genotype/variety	Resistance or tolerance to
Balimau Putih, Ptb 18, Ptb 33, Utri Rajapan, Utri Merah, Tukad Balian, Tukad Petanu, Tukad Unda, *O. officinalis, O. eichingeri, O. minuta*	Green Leaf Hopper (GLH)
Ptb 19, Ptb 19, Ptb 21, Babawee, Mudgo, TKM 6, Kencana Bali, Rathu Heenati, Paedai Kalibungga, Paedai Nggulahi, PTB 33, Barumun, Memberamo, Tajum, Maros, Digul, Ketan Lumb, *O. officinalis, O. eichingeri, O. minuta, O. australiensis*	Brown Plant Hopper (BPH)
O. officinalis, O. eichingeri, O. minuta	Whiteback Planthopper (WBPH)
Si Topas, *O. nivara, O. latifolia*	Ragged stunt Virus (RGSV)
Tetep, Tadukan, Carreon, Klemas, Genjah Lampung, Seratus Malam, Sirendah, Sibuah, Batang Ombilin, *O. nivara*, and *O. rufipogon*	Rice blast
IRBB5, IRBB7, We Shang, IR66738, Cing Lonic, Lemo, Si Topas, Si Redep, Bengawan, Papah Aren, Rojolele, Baso, Acc4375, Siam 29, Aceh-Aceh, Sipulut, RP 1837-715, Way Apo Buru, Angke, Logawa, Mekongga, Memberamo, Ase Balacung, Apel, Cibodas, Barito, IR42,Kapuas, Pelopor, Nolokario, *O. glaberrima, O. nivara, O. glumaepatula, O. barthii, O. Minuta, O. officinalis*	Bacterial leaf Blight (BLB)
Mauay Nangh, Warangal	Gallmidge
Salumpikit, Tera, Modok, Cabacu, Hawara Bunar, Mujahir, Bendang Lamek, Si Karo-karo, Ampera, Si Jongkong, Si Angkat, Si Latihan, Guarani, Centro America, Randah Sarra, Serendah, Meurak Petani, Pelai, Way Rarem, Jatiluhur, Silugonggo, Harapan, Kalimutu, B10-Sm-1-c, TB154E-Tb-1, TB154E-Tb-2, IR2071-588-6, Parai Salak, B8213g-Kn-11, *O. glaberrima*,	Drought
Mahsuri, BW 267-3, Kapuas, KDM 105, Batang Ombilin	Fe
Nona Bokra, Pokkali, Pucuk dan Pelita I-1, IR42	Salinity
Pandan wangi, Rojolele, Bengawan Solo, B9645 dan B9307, B8202, Khao Dawk Mali, IR738, Seratus Malam, B10302	Aromatic
IR29, IR65, Lusi, Ayung, Ketonggo, Setail, Ciasem	Sticky rice
Jatiluhur, B6824E-TB-3, Kencana, Ketan Tawa, Sidomuncul, Ketan Tarling	Shading
Memberamo, IR841, IR64, KDM 105, Cabacu, Barumun, Bengawan Solo, Cisadane, Cibodas	Good quality
Silewah, Batang Ombilin, Batang Sumani	Cold
B9281F-KN-19-3-2, B7876D-MR-99-KN-2, B9154F-PN-MR-1-1-8, IR24637-3B-2-3-1, Cisantana, IR64	Lodging
Hawara Bunar, Azucena, IRAT 144, IRAT 303, IRAT 351, IRAT 352, IRAT 379, IAC 1246, Pulutan, Pare Pulug Lia, Pare Bulan, Padai Mahak, Padai Pulut Saleng Kelambu, Padai Jaweng, Padai Putih, Ketan Merah, Kelai, Ketan Besar	Al
Angkong, Ketan Mas, Tiga Dara, Cere Putih, Rojolele, Cisadane, Memberamo, Celebes, Sintanur, Cimelati, Gilirang, Dendang, Sri Kuning, Si Gupai Kandang.	Low amylose content ($\leq$20%)
Sewalan, Markoti, Gedangan Lulut, Tholo, Mujahir, Bengkok, Srogel Abang, Sampang Kuning, Luwuk, Tb. 160E-Tb-2, Jalawara, Komas, Sariname	Long panicle
Ketan Bodas, Padi Pejet, Engseng, Serai Kuning, Limar, Cibodas, Ciapus, Pare Siang, Rencong, Sereh, Seseka Kalendeo,	Big grain (1.000 seed weight $\geq$30 g)
IR64, Digul, Way Apoburu, Ciherang, Celebes, Singkil, Konawe, Wera, Mekongga, Situbagendit	Long grain

Sources: Daradjat *et al.* (2009), Silitonga *et al.* (2001), Silitonga (2004), Suardi and Silitonga (1999), Suardi and Abdullah (2003), Suardi *et al*. (2004), Utami *et al*. (2005).

the Indonesian rice landraces composed of 68% indica and 32% tropical japonica with an indica gene diversity 0.53 and a tropical japonica gene diversity 0.56. Research experiences indicated that a large number of SSR markers are needed in the analysis of genetic variability to obtain more variations in the number of alleles and bands that affect the *Polymorphism Information Content* (PIC) value. Another number of 190 accessions had also been used in the SSR genotyping, including 183 rice landraces from Kalimantan and 7 other rice varieties as controls (Thomson *et al*. 2009).

A number of 85 accessions of wild rice species had been analyzed their genetic diversities using microsatellite markers. Results of the DNA polymorphisms showed 230 alleles ranging from 6 to 31 alleles for each primers. Based on cluster analysis with genetic similarity of 81%, the wild rice species were also classified into two major groups (Prasetiyono *et al*. 2005). Group I composed of *O. glaberrima, O. barthii, O. nivara, O. rufipogon, O. glumaepatula,* and *O. australiensis*, while group II consisted of *O. eichingeri, O. grandiglumis, O. alta, O. officinalis, O. latifolia, O. ridleyi, O. malampuzhaensis, O. rhizomatis, O. punctata,* and *O. minuta.*

A large number of rice germplasm had been evaluated for their resistance or tolerance to various biotic and abiotic stresses, including brown plant hopper (BPH), leaf blast (Bl), and panicle blast (PB), bacterial blight (BB), rice tungro virus (RTV) alkali injury (Alk), salt injury (Sal), iron toxicity (Fe tox), low pH, and drought tolerance (DRT) based on the Standard Evaluation System for Rice (IRRI 1996). Evaluation of wild rice species showed that *O. officinalis* were resistant to BB, and also to BPH. *O. minuta* was resistant to *Xanthomonas oryzae* pv. *oryzae*, Indonesian strain IV and VIII, the BB pathogen and also resistant to rice blast. Utami *et al.* (2005)

Table 2. Genetic variability parameters of 96 rice accessions analyzed using 30 SSR markers.

Panel	Marker	Allele size (bp)	Major allele frequency	No. of allele	Gene diversity	Heterozygousity	PIC value
1	RM5	108-132	0.351	9	0.773	0.043	0.741
1	RM433	212-228	0.810	4	0.325	0.022	0.300
1	RM55	201-243	0.637	11	0.564	0.042	0.538
1	RM215	127-157	0.747	12	0.690	0.042	0.650
1	RM514	246-272	0.411	8	0.727	0.042	0.686
2	RM214	88-158	0.768	15	0.405	0.011	0.399
2	RM11	122-146	0.453	9	0.740	0.021	0.715
2	RM144	160-277	0.527	14	0.665	0.043	0.632
2	RM237	115-151	0.536	12	0.657	0.052	0.624
2	RM171	321-345	0.533	6	0.645	0.011	0.602
3	RM133	227-233	0.489	4	0.557	0.053	0.459
3	RM287	83-117	0.272	12	0.828	0.011	0.808
3	RM259	145-177	0.447	12	0.721	0.021	0.687
3	RM250	138-178	0.734	16	0.450	0.032	0.439
3	RM507	224-260	0.811	5	0.322	0.021	0.294
4	RM161	143-179	0.806	10	0.343	0.000	0.334
4	RM283	95-167	0.718	9	0.462	0.021	0.439
4	RM124	259-297	0.441	7	0.649	0.022	0.582
4	RM162	189-241	0.495	13	0.676	0.000	0.636
4	RM277	106-126	0.704	6	0.471	0.011	0.437
5	RM431	241-265	0.478	9	0.701	0.000	0.666
5	RM154	100-226	0.266	22	0.863	0.011	0.851
5	RM484	292-310	0.810	5	0.323	0.000	0.296
5	RM105	89-137	0.525	7	0.656	0.013	0.616
5	RM536	226-266	0.458	10	0.712	0.011	0.677
6	RM125	104-149	0.760	8	0.403	0.039	0.379
6	RM19	194-260	0.380	9	0.782	0.013	0.757
6	RM541	104-192	0.560	14	0.653	0.011	0.631
6	RM413	76-182	0.321	10	0.784	0.000	0.752
6	RM474	228-280	0.313	17	0.819	0.016	0.799
	Mean	165.4-211.7	0.543	10.2	0.612	0.021	0.581

Source: Septiningsih *et al*. (2004).

Table 3. SSR diversity and population differentation across the different sub-groups of East Kalimantan rice landraces using 30 SSR loci.

Sub-groups	Sample size	Mean no alleles/locus	Major allele frequency	Mean of gene diversity	Mean of PIC value	Fst
All Kalimantan landraces (indica and japonica)	183	5.0	0.63	0.49	0.44	0.59
Indica	36	2.6	0.79	0.30	0.26	
Japonica	147	4.5	0.74	0.35	0.31	
All Kalimantan landraces (Bahau and Kayan rivers)	183	5.0	0.63	0.49	0.44	0.03
Upper Bahau landraces	82	4.3	0.63	0.49	0.44	
Lower Bahau landraces	45	3.9	0.71	0.38	0.35	
Kayan landraces	56	4.3	0.59	0.53	0.47	

Sources: Thompson *et al.* (2009).

reported that *O. rufipogon* Griftt was also resistant to blast, and it has been introgressed into the cultivated rice. Gene *Pirf2-1* on *O. rufipogon* contributed a dominant mode of resistance to blast which was affected by a duplicate epistasis and the other gene *Pir2-3 (t)* contributed an additive which was affected by a complementary epistasis. Another experiment by Utami *et al.* (2007) showed *that Pir 1 and Pir 2* segregated on 1 : 1 proportion related to specific respond of blast *avr* gene *PH 14* and *CM 28* resistance. Information on rice genetic variation based on DNA finger printing by using conserve-motion region of resistance gene was reported by Bustamam *et al.* (2004). It was indicated that at 86% level of similarity, blast resistant varieties like Cabacu, Gajah Mungkur, Jambu, Hawara Bunar, Grogol and Mat Embun were in the same cluster. Blast resistance gene *Pi-1* and *Pi-2* had been incorporated into Cabacu, Way Rarem, and Jambu varieties (Bustamam *et al.* 2005). None of the wild rice species, however, was resistant to the Indonesian *Pyricularia oryzae* race 073 and 173 from Sukabumi, West Java (Abdullah *et al*. 2003). The differences in resistance or tolerance to biotic and abiotic stresses among the rice germplasm were reported by many scientists in Indonesia (Abdullah 2002, Abdullah *et al.* 2003, Suardi *et al.* 2004).

Suardi *et al.* (2004) had evaluated 87 accessions of wild rice for root penetration ability; two of them, *O. glaberrima*, IRRI accs. No. 101297 and *O. nivara*, IRRI accs. No. 103282 showed the highest root penetration ability on polyethylene glycol (PEG) solution at a 32.5% concentration. The root penetration ability of *O. glaberrima* was almost the same as the control variety IRAT 112 (Gajah Mungkur), which is tolerant to drought.

UTILIZATION OF RICE GERMPLASM

The diverse rice germplasm available in the genebank of ICABIOGRAD plays an important role as gene resources for rice improvement in the breeding program to develop high yielding rice varieties resistant or tolerant to biotic and abiotic stresses as well as good quality. Although most of the rice germplasm have been characterized and evaluated conventionally and using molecular markers, the parentages used in the breeding program generally are not variable enough and have close relationships among each other. For examples, varieties Cimelati, Gilirang, and Ciapus, which were released in 2001, 2002, and 2003 respectively, were the improvement of variety Memberamo (Figure 1), and other 20 high yielding varieties (Digul, Maros, Batang Anai, Way Apo Buru, Towuti, Cisantana, Ciherang, Konawe, Singkil, Wera, Ciujung, Angke, Code, Batang Gadis, Sunggal, Cigeulis, Cibogo, Batang Lembang, Pepe, and Mekongga) that had been improved using IR64. These are the reasons for the many high yielding varieties to look like the same. Unfortunately, many of these varieties were no longer exist in the field, only one or two years grown by the farmers. It is important, therefore, to use other gene sources, especially from the wild rice relatives as parents in breeding for new high yielding varieties tolerant to biotic and abiotic stresses. The more new varieties with variable genetic background are released, the more chances the farmers had choose their preference varieties.

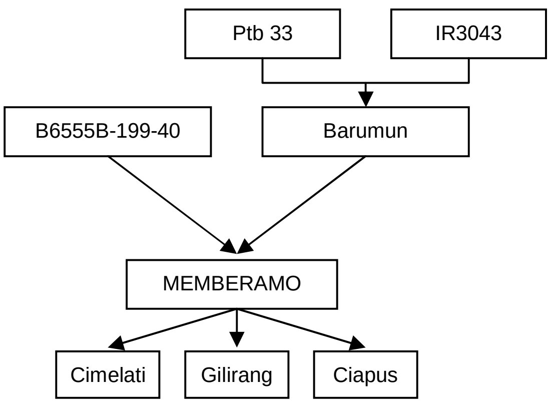

Figure 1. Flowchart of breeding program of rice variety Memberamo and its relatives.

The utilization of rice germplasm in the breeding program conventionally have resulted several improved high yielding varieties for the farmer. Since the year of 2006 up to 2009 there are 31 rice varieties have been improved and released. 17 varieties of them are hybrid rice, and 14 varieties are non hybrid rice.

Beside using by breeders, rice germplasm were also used by university for research. Some local rice varieties with important value such as good quality, high protein and iron content on rice (red and black rice), aromatic rice are also grown by farmers. For example: red rice varieties Mandel, Segreng and Cempo Merah are always grown in Sleman, Yogyakarta, aromatic rice and good eating quality such as Pandan Wangi in Cianjur; Rojolele and Mentik in Yogyakarta and Central Java; Arias, Si Ramos, and Si Kodok in North Sumatra; and Mayas in Kalimantan. Those varieties are usually grown in broad scale and even some as organic farming system that resulted in high price. This condition have increased the farmers income and attained their food security. As a result, poverty alleviation could be achieved by planting various high yielding varieties that could be selected by farmers to be grown in their specific land.

Beside using conventionally, rice breeding also using anther culture techniques to determine regeneration ability of indica rice tolerance to aluminium (Dewi *et al.* 2006), and to develope double haploid population and blast resistant lines (Ambarwati *et al.* 2009). A cross between an Al tolerant variety Dupa and a sensitive variety ITA 131 have resulted 190 lines. About 94 of F-2 plants have been tested to investigate their quantitative trait loci (QTL) position for Al tolerance (Prasetiyono *et al.* 2003). The linkage of DNA markers with tolerance to iron (Fe) on rice have also been tested and resulted that two markers *RG144* and *RZ612* linked QTL for iron toxicity tolerance (Hanarida *et al.* 2001). The genetic transformation technology mediated by *Agrobacterium* have resulted 17 independent transgenic lines of rice mutant (Sisharmini *et al.* 2009).

DOCUMENTATION AND EXCHANGE OF GERMPLASM INFORMATION

A database management system has been designed to manage the rice germplasm collection of ICABIOGRAD more efficiently. The managed data recording, retrieval, storage, and maintenance. The database contained a whole range of Genebank data operations, including exploration, collection, multiplication, conservation, rejuvenation, characterization, evaluation, and distribution to the user. The system was aimed to assist the Genebank staff in day-to-day activities, to provide users to direct access information to the collections, and to allow the users to request the desired germplasm.

The system was run through a local area network (LAN) that have been initiated by the establishment of INDOPLASMA (www.indoplasma.or.id) of the National Committee of Genetic Resource and the National Information Sharing Mechanism on the implementation of the Global Plan of Action (NISM-GPA). The exchange of information about rice germplasm should be encouraged through networks and other means.

CONCLUSIONS

A large number of rice germplasm had been conserved, characterized and evaluated at the ICABIOGRAD conventionally and using molecular techniques their morphological and agronomic characters and also their resistance or tolerance to various biotic and abiotic stresses, including brown plant hopper (BPH), leaf blast (Bl) and panicle blast (PB), bacterial blight (BB), rice tungro virus (RTV), alkali injury (Alk), salt injury (Sal), iron toxicity (Fe tox), low pH, and drought tolerance (DRT). Characterization and identification using molecular techniques had also applied to analyze genetic diversities of the germplasm. A database management system has been designed to manage the rice germplasm and to provide users to direct access information to the collections, and also to allow to request the desired germplasm. The utilization of rice germplasm in the breeding program have resulted several improved high yielding varieties for the farmer and transgenic lines. Since the year of 2006 up to 2009 there are 31 rice varieties have been improved and released. 17 varieties of them are hybrid rice, and 14 varieties are non hybrid rice.

Future crop improvement needs genetic variation from traditional rice germplasm and related wild species of rice in the breeding program to cope with the many biotic and abiotic stresses, dwarf with good plant type that challenge rice production in Indonesia. Creating many better high yielding varieties will reserve many varieties to choose by the farmer.

The use of biotechnology in the characterization, evaluation, and utilization should be explored and intensified to take the advantage of the rapid development in biotechnology.

Collaboration through networks, programs, and agreements for conserving and utilization of rice germplasm should be continued nationally, regionally and internationally.

REFERENCES

Abdullah, B. 2002. Wild species *Oryza* spp. a prospective source of bacterial blight resistance for rice breeding. Penelitian Pertanian Tanaman Pangan 21(3):1-5.

Abdullah, B., M. Bustamam, T.S. Silitonga, Bahagiawati, D. Suardi, J. Prasetiyono, Tasliah, M. Amir, dan A. Nasution. 2003. Evaluasi dan karakterisasi ketahanan spesies padi liar terhadap cekaman biotik dan abiotik dengan menggunakan kultur *in vitro* dan markah molekular. Laporan Hasil Penelitian, Balai Penelitian Bioteknologi dan Sumberdaya Genetik Pertanian. 25 hlm.

Abdullah, B., S. Kartowinoto, dan Budiarto. 1997. Penyelamatan plasma nutfah kedelai melalui teknik *in vitro*. Jurnal Bioteknologi Pertanian 2(2):56-60.

Ambarwati, A.D., I.H. Somantri, D.W. Utami, A. Apriana, and S. Moeljopawiro. 2009. Rice anther culture to develop double haploid population and blast resistant lines. Jurnal Agrobiogen 5(2):71-77.

Bustamam, M., Reflinur, D. Agisimanto, dan Suyono. 2004. Variasi genetik padi tahan blas berdasarkan sidik jari DNA dengan markah gen analog resisten. Jurnal Bioteknologi Pertanian 9(2):56-61.

Bustamam, M., Reflinur, D. Agisimanto, E. Lubis, and Suwarno. 2005. Application of molecular marker for the assessment of blast resistance genes, Pi-1 and Pi-2, incorporated into Indonesian rice cultivars. Jurnal Bioteknologi Pertanian 10(2):51-54.

Daradjat, A.A., T.S. Silitonga, dan Nafisah. 2009. Plasma nutfah untuk perbaikan varietas padi. *Dalam* Daradjat, A.A., A. Setyono, A.K. Makarim, dan A. Hasanuddin (*Eds*.). Padi. Balai Besar Penelitian Tanaman Padi, Badan Penelitian dan Pengembangan Pertanian. hlm. 1-27.

Dewi, I.S., B.S. Purwoko, H. Aswidinnoor, dan I.H. Somantri. 2004. Kultur antera padi pada beberapa formulasi media yang mengandung poliamin. Jurnal Bioteknologi Pertanian 9(1):14-19.

Dewi, I.S., B.S. Purwoko, H. Aswidinnoor, I.H. Somantri, dan M.A. Chosin. 2006. Regenerasi tanaman pada kultur antera beberapa aksesi padi indica toleran aluminium. Jurnal Agrobiogen 2(1):30-35.

Hanarida, I.S., Sutrisno, T. Suhartini, Sustiprijatno, S. Rianawati, K.R. Trijatmiko, dan T.J. Santoso. 2001. Keterpautan marka DNA dengan sifat toleran terhadap keracunan besi pada padi. Jurnal Bioteknologi Pertanian 6(1):22-28.

International Rice Research Institute. 1995. Genetic Resources Center. Manual of Operations and Procedures of the International Rice Genebank, IRRI Los Banos, Philippines. 116 p.

International Rice Research Institute. 1996. Standard Evaluation System for Rice. INGER, Genetic Resources Center, 4th ed. IRRI, Los Banos Philippines. 52 p.

Lu, B.R. and T.S. Silitonga. 1999. First record of the wild rice *Oryza meridionalis* in Indonesia. International Rice Research Newsletter (IRRN) 24:3. International Rice Research Notes. IRRI, MCPO Box 3127, Makati City 1271, Philippines.

Maunder, M. 2001. Plant Conservation. Encyclopedia of Biodiversity 4:645-658.

Prasetiyono, J., Tasliah, H. Aswidinnoor, dan S. Moeljopawiro. 2003. Identifikasi marka mikrosatelit yang terpaut dengan sifat toleransi terhadap keracunan aluminium pada padi persilangan Dupa x ITA 131. Jurnal Bioteknologi Pertanian 8(2):35-45.

Prasetiyono, J., Tasliah, M. Bustaman, T.S. Silitonga, dan B. Abdullah. 2005. Analisis keragaman genetik spesies padi liar menggunakan markah mikrosatelit. Penelitian Pertanian Tanaman Pangan 24(3):168-174.

Septiningsih, E.M., T.J. Santosa, D.W. Utami, and N. Hidayatun. 2004. DNA-finger printing Analysis of Food Crops. A Research Report. Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development, Bogor.

Silitonga, T.S. 2002. Exploration and collection for wild rice species in Irian Jaya. Buletin Plasma Nutfah 8(1):34-39.

Silitonga, T.S. 2004. Pengelolaan dan pemanfaatan plasma nutfah padi di Indonesia. Buletin Plasma Nutfah 10(2):56-71.

Silitonga, T.S., S.G. Budiarti, S.A. Rais, dan Asadi. 2001. Sumberdaya genetik untuk perbaikan dan perakitan varietas unggul baru tanaman pangan. Buletin Plasma Nutfah 7(1):26-39.

Sisharmini, A., A. Apriani, W. Enggarini, dan K.R. Trijatmiko. 2009. Pengembangan populasi mutan penanda aktivasi: I. Transformasi padi Japonica tropis lokal Sulawesi c.v. Asemandi dengan bantuan *Agrobacterium tumefaceiens*. Jurnal Agrobiogen 5(2):49-56.

Suardi, D. dan T.S. Silitonga. 1999. Daya tembus akar plasma nutfah padi lokal. Buletin Plasma Nutfah 4(1):45-50.

Suardi, D. dan B. Abdullah. 2003. Padi Liar tetua toleran kekeringan. Buletin Plasma Nutfah 9(1):33-38.

Suardi, D., T.S. Silitonga, B. Abdullah, dan T. Suhartini. 2004. Evaluasi spesies padi liar toleran kekeringan. Penelitian Pertanian Tanaman Pangan 23(1):23-27.

Suhartini, T., I.H. Somantri, dan B. Abdullah. 2003. Rejuvenasi dan karakterisasi plasma nutfah spesies padi liar. Buletin Plasma Nutfah 9(1):16-25.

Thomson, M.J., E.M. Septiningsih, F. Suwardjo, T.J. Santoso, T.S. Silitonga, and S.R. McCouch. 2007. Genetic diversity analysis of traditional and improved Indonesian rice (*Oryza sativa* L.) germplasm using microsatellite markers. Theor. App. Genet. 114:559-568.

Thomson, M.J., N.R. Polato, J. Prasetiyono, K.R. Trijatmiko, T.S. Silitonga, and S.R. McCouch. 2009. Genetic diversity of isolated populations of Indonesian landraces of rice (*Oryza sativa* L.) Collected in East Kalimantan on the Island of Borneo. Rice 2(1):80-92.

Utami, D.W., S. Moeljopawiro, H. Aswidinnoor, A. Setiawan, dan I. Hanarida, 2005. Gen Pengendali sifat ketahanan penyakit blas (*Piricularia grisea* Sacc.) pada spesies padi liar *Oryza rufipogon* Griff. dan padi budidaya IR64. Jurnal Agrobiogen 1(1):1-6.

Utami, D.W., A.D. Ambarwati, A. Apriana, A. Sisharmini, I. Hanarida, D. Tharreau, dan Santosa. 2007. Spektrum ketahanan galur haploid ganda turunan IR64 dan *O. rufupogon* yang mengandung QTL ketahanan terhadap penyakit blas (*Pir*). Jurnal Agrobiogen 3(1):1-8.

Vaughan, D.A. 1994. The Wild Relative of Rice. A Genetic Resources Handbook. IRRI, Los Banos, Laguna, Philippines, 137 p.