Wild Rice (*Oryza* spp.): Their Existence and Research in Indonesia

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ABSTRAK

Padi Liar *(Oryza* spp.*):* Keberadaan dan Penelitiannya di Indonesia. *Ida Hanarida Somantri.* Padi adalah tanaman serealia penting dan digunakan sebagai makanan pokok oleh sepertiga penduduk dunia. Genus *Oryza* di mana padi budi daya termasuk didalamnya mempunyai sekitar 24 spesies liar. Keberadaan spesies padi liar telah dilaporkan, tetapi eksplorasi yang terbaru telah dilakukan pada tahun 1998 dan 1999 di Sulawesi dan Irian Jaya, terutama untuk koleksi padi liar. Eksplorasi dilakukan dalam rangka kerja sama antara Puslitbangtan dan IRRI. Satu spesies *Oryza meyeriana* dan empat spesies lainnya (*O. officinalis, O. longiglumis, O. rufipogon*, dan *O. meridionalis*) telah ditemukan di Sulawesi dan Irian Jaya. *O. meredionalis* merupakan penemuan pertama di Indonesia, sebelumnya hanya dilaporkan ada secara endemik di pantai utara Australia. Penelitian untuk perbaikan padi yang melibatkan spesies padi liar belum begitu berkembang di Indonesia. Namun demikian, beberapa persilangan antara padi budi daya dan padi liar serta evaluasi terhadap cekaman biotik dan abiotik telah dilakukan. Telah pula dihasilkan benih hasil persilangan padi budi daya dengan *O. officinalis, O. australiensis, O. grandiglumis, O. latifolia, O. punctata, O. brachyanta, O. alta, O. glumaepatula*, dan *O. malamphuzaensis.*

Kata kunci: *Oryza* sp., padi liar, Indonesia

Rice is one of the important cereal crops, and is used as staple food of one third of the world population. In Indonesia, rice con-stitutes strategic food commodities and is given high priority in agricul-tural development.

Cultivated rice, *Oryza sativa,* has approximately 24 wild species (Khush, 1997). Vaughan (1994) in-cluded Indonesia as a major distri-bution area for wild races. These races were spread in large islands, such as Sumatra, Kalimantan, Java, Irian Jaya (Papua), and even in Maluku. Specimens of wild rice collected from Indonesia are kept in several of the world's major herbaria.

The genetic variability of culti-vated rice germplasm for important traits, such as resistances to tungro, sheath blight, yellow stem borer, drought, and salinity, were very limited if any (Brar, 1990).

Wild races that are grown under a wide range of agro-climatic conditions have important traits, which are very useful in enriching the genetic variability of *Oryza sativa*. Combining of two different genomes of *Oryza* sp. can be done through crossing or by protoplast fusion. Although crossing is easier than protoplast fusion, difficulties are still found in crossing system due to the differences in number and type of chromosome that pos-sibly create incompatibility. Basic-ally, the difficulties are defined into pre-fertilization barrier and post-fertilization barrier (Khush and Brar, 1988). A number of techniques have been devised to overcome cross ability barrier and to produce viable hybrids between incompat-ible species. The abortion of em-bryos at different stages of develop-ment is a characteristic feature of wide crosses, including rice. Em-bryo rescue is therefore an import-ant step to overcome this problem. However, crosses of a genome of wild species with cultivated rice usually do not require embryo res-cues to obtain F1 hybrids.

The use of wild species of rice in supporting rice breeding program to increase the genetic variability has been practiced. Some research activities have been done, such as crossing a number of cultivated rice (Indica and Javanica) with wild rice species, characterization of morph-ological traits, and evaluating the resistance of a number of wild rice species to major pests and dis-eases, such as brown plant hopper (*Nilaparvata lugens*), blast (*Pyricu-laria oryzae*), and bacterial blight (*Xanthomonas oryzae* pv. *oryzae*).

EXISTENCE OF WILD RICE IN INDONESIA

Indonesia is a part of the Vavilov Centre of Diversity (VCD) that contains about nine percents genetic diversity found in the VCD. Indonesia is, therefore, known as a nation with mega biodiversity con-sisting of more than 28,000 plant species (KMNLH, 1993). Rice (*Oryza* spp.) is one of thousandth plant species grown in Indonesia.

Many collectors have reported the existence of *Oryza* spp. includ-ing its wild type since 1800. The first species of wild rice collected from Java was *Oryza meyeriana*, which was collected by H. Zollinger in 1842. This species is now kept at the British Museum (Natural His-tory) in London, UK (Vaughan, 1994). Vaughan (1994) also reported that *Oryza meyeriana* and other specimens of wild species of *Oryza,* such as *O. granulata* and *O. ridleyi* are kept in some of the world's major herbaria, such as in the Herbarium Bogoriense, Bogor; the Gray Herbarium of Harvard Uni-versity, Cambridge, Massachusetts, USA, and Rijksherbarium, Leiden, The Netherlands (Table 1).

According to Vaughan (1994), the *Oryza* spp. was distributed in almost all of the larger islands in Indonesia. Some of the recorded species were *O. meyeriana, O. granulata, O. longiglumis, O. rufipogon, O. officinalis, O. ridleyi*, and *O. schlechteri* (Table 2).

The International Rice Research Institute (IRRI) has been collab-orating actively with the Central Research Institute for Food Crops (CRIFC), Bogor, of the Agency of Agricultural Research and Develop-ment (AARD), in exploring and collecting rice germplasm, includ-ing the wild rice species. The co-operative collecting missions have been conducted by staffs of both institutions in West Java (Vaughan, 1988b), South Sumatra (Vaughan, 1989), North Sumatra (Vaughan, 1990), West Kalimantan (Vaughan, 1992), Central Sulawesi (Lu, 1998), and Irian Jaya (Lu and Silitonga, 1999a).

During the four-time explorations, Vaughan (1988a, 1989, 1990, and 1992) found and collected at least five species of wild rice, i.e., *O. rufipogon*, *O. officinalis*, *O. ridleyi*, *O. granulata*, and *O. meyeriana*. Lu (1998) found and collected only one species of wild rice, *O. meyeriana,* from Central Sulawesi. Actually, Central Sulawesi was not a target of the mission. The mission was previously targeted to Papua, but due to some problems that happened in the area in 1998, the collection was postponed to 1999. Four wild *Oryza* spp. were found and collected from Merauke sub district of Papua, i.e., *O. officinalis*, O. *meridionalis, O. rufipogon*, and *O. longiglumis*.

Previously, *O. meyeriana* was reported to spreads only in South Sulawesi (Vaughan, 1994), but later it was also found in Central Sulawesi. *O. meridionalis* has only been reported as endemic to the northern part of Australia. This finding is, therefore, the first documentation that *O. meridionalis* also has distribution in Irian Jaya, Indonesia (Lu and Silitonga, 1999a; 1999b).

The wild rice found and collected by Lu and Silitonga (1999a, 1999a) are perennial and diploid (2n = 2x = 24), except *O. longiglumis* as a tetraploid (2n = 4x = 48) contain-ing HHJJ genome (Agarwal, *et al*., 1996; Khush, 1997). The genome type is shown in Table 3.

Wild *Oryza* species from Indonesia are also conserved in the International Rice Germplasm Center of IRRI as reported by Vaughan (1994) and shown in Table 4.

The distribution of wild species in Indonesia could be illustrated as Figure 1.

Table 1. Specimens of wild rice species, *Oryza* spp. from Indonesia, which are found in some of the world's major herbaria (Vaughan, 1994)

Species	Herbarium
Oryza granulata	BO, L, GH
O. meyeriana	SING, L, BM, BO, US, P, K, GH, LAE
O. ridleyi	BM, BO, GH, US, K, L, SING, P

BO = Herbarium Bogoriense, Lembaga Biologi Nasional, Bogor, Indonesia; L = the Rijksherbarium, Leiden, The Netherlands; GH = The Gray Herbarium of Harvard University, Cambridge, Massachusetts, USA; SING = Herbarium of the Botanic Gardens, Singapore; BM = The British Museum (Natural History), London; US = The Smithsonian Institute, Washington; P = Museum National d'Histoire Naturelle, Laboratoire de Phanerogamie, Paris, France; K = The Royal Botanic Gardens, Kew, Surrey; LAE = The Papua New Guinea National Herbarium, Lae, Papua New Guinea

Table 2. The distribution of wild rice in Indonesia

Species	Location
Oryza meyeriana	North Sumatra, South Kalimantan, West Java, East Java, Flores and South Sulawesi
O. granulata	West Java, East Java, and Central Java
O. longiglumis	Irian Jaya
O. officinalis	Sumatra, Java, Kalimantan, North Maluku, and Flores
O. ridleyi	Sumatra, West Kalimantan, East Kalimantan, and Irian Jaya
O. rufipogon	South Sumatra, West java, West Kalimantan, and South Kalimantan
O. schlechteri	Irian Jaya

Source: Vaughan (1994)

WILD RICE RESEARCH IN INDONESIA

Rice germplasm is not fully utilized yet in rice breeding program in Indonesia, especially for wild rice species. Sometime the variation of cultivated germplasm is very limited or the important genes like stem borer and tungro virus-resistance genes are not available. The genus *Oryza* to which cultivated rice (*O. sativa* 2n =24 AA genome) belongs has about 24 wild species having very useful traits (Table 5).

Although research on wild rice in Indonesia has not developed yet the research towards this topic has been initiated. It is realized that using the wild species for rice improvement needs additional knowledge and skill due to the difficulties aroused in crossing step because of the difference in chromosome number and the type of genome. Beside, the knowledge on biotech-nological method particularly in molecular identification that usually used in evaluating progeny is a necessary.

Up to date the researches on wild rice that have been conducted are as follows: crossing cultivated

Table 3. The genome type of wild rice from Indonesia

Species	2n	Genome
Oryza officinalis	24	CC
O. meyeriana	24	GG
O. longiglumis	48	HHJJ
O. rufipogon	24	AA
O. meridionalis	24	A^mA^m
O. ridleyi	48	HHJJ
O. spontanea	24	AA
O. schlechteri	48	unknown

Table 4. Wild *Oryza* species from Indonesia conserved in the International Rice Germplasm Center, IRRI (Dec. 1991)

Species	Number of accessions
Oryza longiglumis	5
O. officinalis	49
O. ridleyi	2
O. rufipogon	10
O. spontanea and hybrid populations	2
Oryza spp.	1

Source: Vaughan (1994)

○ = *O. granulata*; △ = *O. longiglumis*; □ = *O. meyeriana*; ▽ = *O. officinalis*, ★ = *O. ridleyi*; ⬡ = *O. rufipogon*; ⊏⊐ = *O. schlechteri*; ⇨ = *O. meridionalis*

Figure 1. Distribution of wild species in Indonesia

rice of Indica or Javanica with some wild rice species, characterizing morphological traits and evaluating the biotic and a biotic stress.

It is documented that IRRI successfully produced more than fifteen (15) hybrid inter specific through embryo rescue. Based on the IRRI's results, some crossing activities have been done using wild species (Hanarida and Ambarwati, 1992a; 1992b; Hanarida and Abdullah, 1992; Abdullah and Hanarida, 1995; Hanarida *et al.*, 1996) with the purposes to practice the embryo rescue method, to increase the genetic variability of rice species and at the same time to provide material to get lines of rice wild that have good traits. Table 6 shows some crossing results that have been conducted. With the same purposes Hanarida and Rodiyah (2000) conducted crossing between cultivated rice and other

Table 5. Chromosome numbers, genome composition, distribution areas, and potential useful traits of *Oryza* spp.

Species	2n	Genome	Distribution	Useful Traits [a)]
Oryza sativa complex				
O. sativa L.	24	AA	World wide	Cultigen
O. glaberrima Steud.	24	AA	West Africa	Cultigen
O. nivara Sharma et Shastry	24	AA	Tropical and Sub Tropical Asia	Resistance to grassy stunt and blast, and drought avoidance
O. rufipogon Griff.	24	AA	Tropical and Sub Tropical Asia, Tropical Australia	Resistance to BB, elongation ability, source of CMS
O. brevilugata A. Chev. et Roehr	24	A^gA^g	Africa	Resistance to GLH, BB, drought avoidance
O. glaberrima Steud	24	A^gA^g	Tropical West	Cultigen
O. longistaminata A. Chev. et Roehr	24		Africa	Resistance to BB; drought ovidance
O. meridionalis Ng.	24	A^mA^m	Tropical Australia	Elongation ability; drought avoidance
O. glumaepatula Steud.	24	$A^{gp}A^{gp}$	South and Central America	Elongation ability; source of CMS
O. officinalis complex				
O. punctata Kotschy ex Steud.	24	BB	Africa	Resistance to BPH
O. minuta J.S. Presl. ex C.B. Presl.	48	BBCC	Philippines, Papua New Guinea	Resistance to BB, BPH, GLH, and sheath blight
O. officinalis Wall ex Watt	24	CC	Tropical and Sub Tropical Asia, Tropical Australia	Resistance to thrips, BPH, GLH, WBPH
O. rhizomatis Vaughan	24	CC	Sri Lanka	Drought resistance rhizomatous
O. eichingeri A. Peter	24	CC	South Asia and East Africa	Resistance to yellow dwarf virus, BPH, WBPH, GH
O. latifolia Desv.	48	CCDD	Central and South America	Resistance to BPH, high biomass production
O. alta Swallen	48	CCDD	Central and South America	Resistance to thrips, stem borer, high biomass production
O. grandiglumis (Doel) Prod.	48	CCDD	South and Central	High biomass production
O.australiensis Domin	24	EE	Tropical Australia	Drought avoidance resistance to BPH
O. brachyantha A. Chev. et Roehr	24	FF	Africa	Resistance to yellow stem borer, leaf folder, and whorl maggot; tolerance to lateritic soil
O. meyeriana complex				
O. meyeriana (Zoll. et Mor. ex. Steud.) Baill	24	GG	Southeast Asia	Shade tolerance, adaptation to aerobic soil
O. Granulata Nees et Arn. ex Watt	24	GG	South and Southeast Asia	Shade tolerance, adaptation to aerobic soil
O. ridleyi complex				
O. longiglumis Jarisen	48	HHJJ	Irian Jaya, Indonesia, and Papua New Guinea	Resistance to blast, BB
O. ridleyi Hook. F.	48	HHJJ	South Asia	Resistance to stemborer, whorld maggot, blast, and BB
Unknown genome				
O. schlechteri Pilger	48	Unknown	Stoloniferous	

[a)]BPH = brown plant hopper, GLH = green leaf hopper, WBPH = white-backed plant hopper, BB = bacterial leaf blight, CMS = cytoplasmic male sterility

Source: Khush (1997)

Table 6. Results of F1 plant from hybridization between a number of rice cultivars and five wild rice species

Cross combination	The number of flower crossed	Seed set (F1)	Embryo planted (*in vitro*)	F1 plant
IR42/*Oryza officinalis*	259	57	43	12
IR42/*O. australiensis*	150	35	30	0
IR42/*O. grandiglumis*	219	24	24	1
IR42/*O. punctata*	50	3	3	0
IR64/*O. officinalis*	639	62	50	9
IR64/*O. australiensis*	169	7	7	3
IR64/*O. grandiglumis*	347	59	56	16
IR64/*O. latifolia*	53	1	1	1
IR64/*O. punctata*	53	2	2	1
IR64/*O. brachyantha*	492	43	6	0
IR36/*O. officinalis*	60	3	3	1
IR36/*O. australiensis*	50	3	3	0
IR36/*O. grandiglumis*	53	5	5	4
Cisadane/*O. officinalis*	29	20	20	0
Cisadane/*O. australiensis*	515	81	60	1
Cisadane/*O. grandiglumis*	428	95	72	17
Cisadane/*O. punctata*	78	20	18	2

wild rice species, and the results are shown in Table 7.

Table 6. Continued.

Cross combination	The number of flower crossed	Seed set (F1)	Embryo planted (*in vitro*)	F1 plant
Cisadane/*O. brachyantha*	560	15	13	1
Rojolele/*O. officinalis*	63	5	5	2
Rojolele/*O. australiensis*	71	11	11	0
Pandanwangi/*O. officinalis*	77	13	11	5
Pandanwangi/*O. australiensis*	140	14	14	6
Pandanwangi/*O. grandiglumis*	60	24	20	18
Pandanwangi/*O. punctata*	49	11	11	2
Hawara Bunar/*O. officinalis*	223	10	8	2
Hawara Bunar/*O. grandiglumis*	139	20	13	9
Aselapan/*O. grandiglumis*	110	13	10	10
Sri Tumpuk/*O. officinalis*	46	11	11	3
Sri Tumpuk/*O. australiensis*	48	5	5	0
Total	5499	672	535	126

Table 7. Results of F1 plants obtained from hybridization between a number of popularly cultivated rice varieties and some wild rice species

Cross combination	The number of flower crossed	Seed set (F1)	Embryo planted (*in vitro*)	F1 plant
IR64/*O. australiensis*	516	5	4	1
Cisadane/*O. australiensis*	109	1	1	1
Membramo/*O. australiensis*	161	10	10	7
IR64/*O. alta*	231	15	14	1
Cisadane/*O. alta*	342	2	2	1
Membramo/*O. alta*	295	8	8	2
IR64/*O. alta*	233	6	5	3
Cisadane/*O. minuta*	105	0	0	0
Membramo/*O. latifolia*	113	3	3	1
IR64/*O. minuta*	383	22	19	11
Cisadane/*O. minuta*	422	3	3	1
Membramo/*O. minuta*	49	3	3	2
IR64/*Oryza rhizomatis*	116	2	2	1
Cisadane/*O. rhizomatis*	133	6	5	1
Membramo/*O. rhizomatis*	153	11	10	6
IR64/*O. rufipogon*	138	16	11	3
Cisadane/*O. rufipogon*	85	5	3	0
Membramo/*O. rufipogon*	103	17	16	11

Instead of Indonesian Agricultural Biotechnology and Genetic Resources Research Institute, Bogor Agricultural University has conducted several experiment including characterization of growth and flower-ing behaviour of wild rice species and interspesific hybridizations including morphological, cytological, and isozyme evaluation of F1 interspecific hybrids (Amalliyah, 2000). The experiment was con-ducted in Bogor, West Java. with the result as follow:

- The flowering stage of wild rice species was between 60-75 days, while anthesis period of the species varied, ex. *O. officinalis* (06.00 am), *O. punctata* (10.00 am), *O. malamphuzaensis*. and *O. glumaepatula* (11.00 am), and *O. australiensis* (14.30 pm)
- Qualitative characters on F1 plant seem to be controlled by dominant gene such as leaf sheath colour and awn.

Rusdiansyah (2002) and Utami (2002, personal communication) did the experiment on genetic inheritance of blast resistance of Hawara bunar/*O. glumaepatula* and IR64/*O. rufipogon*. The blast resistance race 033 and 041 in *O. glumaepatula* at least controlled by two dominant genes with complex interaction and two recessive gene with duplicate recessive epistasis, respectively. Whereas the blast resistance race 001 and 033 in *O. rufipogon* was controlled by duplicate dominant epistasis.

The research on the development of new rice gene pool for resistance to biotic and abiotic stresses through genes introgression from wild species into rice cultivars has been done using IRRI introgression materials. The research had successfully identified tungro resistance, BPH resistance, BLB resistance, and tolerance to iron toxicity lines (Table 8).

Research on application of tissue culture and molecular techniques for rice genetic improve-

Table 8. Results from evaluation of 18 IRRI introgression lines for resistance to pest and diseases in Indonesia

Line	Progeny of	Resistance to	Number of lines
IR73382	IR64/*Oryza rufipogon*	BLB (score: 3)	1
IR77981	IR65600-81-5-3-2/*O. minuta*	BLB (score: 3-5)	11
IR65483-111-5-9-2-1-1	IR56/*O. brachyantha*	BLB (score 3-5)	10
IR75868	IR64/*O. glaberrima*	BLB (score: 3-5)	4
IR78567	IR64/*O. glaberrima*		2
IR73678	IR64/*O. rufipogon*	Tungro (infection: 0-20%)	1
IR65483	IR56/*O. brachyantha*	Tungro(infection: 5-30%)	1
IR65484	IR56/*O. brachyantha*	Tungro (infection: 5-30%)	1
IR77981	IR65600-81-5-3-2/*O. minuta*	Tungro (infection: 5-31%)	11
IR65483	IR56/*O. brachyanta*	BPH (score: 3)	4
IR71033	IR31917-45-3-2/*O. minuta*	BPH (score: 3)	2
IR75867	IR64/*O. glaberrima*	BPH (score: 3)	3
IR75868	IR64/*O. glaberrima*	BPH (score: 3)	4
IR75870	IR64/*O. glaberrima*	BPH (score: 3)	3
IR75885	IR64/*O. glaberrima*	BPH (score: 3)	2
IR75886	IR64/*O. glaberrima*	BPH (score: 3)	2
IR75871	IR64/O. glaberrima	BPH (score: 3)	5
IR77981	*IR65600-81-5-3-2/O. minuta*	Fe toxicity tolerance (score: 3-5)	11

ment using wild rice species in the Indonesian Agricultural Biotechnology and Genetic Resources Research Institute, Bogor, Indonesia, is in progress (Silitonga *et al*., 2002).

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