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The origin of weedy rice in Peninsular Malaysia

(Asal usul padi rumpai di Semenanjung Malaysia)

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Key words: RAPD's, PCR method, weedy rice, *padi angin*, wild rice, *O. sativa*, *O. rufipogon*, direct-seeded rice

Abstrak

Masalah padi rumpai yang dikenali sebagai padi angin telah berlaku di dua daripada kawasan utama pengeluaran padi di Semenanjung Malaysia iaitu Projek Barat Laut Selangor dan kawasan pengairan Muda akhir-akhir ini. Ciri utama padi angin ialah biji padinya mudah relai dan infestasi yang teruk boleh mengakibatkan kehilangan hasil yang banyak. Untuk mengetahui asal usulnya, kaedah PCR (tindak balas rantai polimerase) telah digunakan terhadap sampel padi liar, padi angin dan varieti padi moden yang pernah ditanam di kawasan yang berkenaan. Analisis kluster pola jalur RAPD menunjukkan bahawa padi angin lebih menyerupai padi moden dari segi DNA. Hasil kajian menepati hipotesis bahawa padi angin terhasil daripada padi moden. Semasa musim kemarau pada tahun 1980an, kaedah tabur terus kering dan 'padi batat' telah diamalkan oleh petani secara meluas. Penggunaan kaedah ini mungkin faktor utama yang mengakibatkan kewujudan padi angin.

Abstract

The problem of a weedy rice known locally as *padi angin* has emerged in two of the main rice production areas in Peninsular Malaysia, Projek Barat Laut Selangor and the Muda area, in recent years. The main characteristic of *padi angin* is its spontaneous shattering habit, therefore under severe infestation it can result in high yield losses. To determine the origin of this weedy rice, polymerase chain reaction (PCR) method was applied to samples of wild rice, *padi angin* and modern cultivated rice varieties. Cluster analysis of randomized amplified polymorphic DNA (RAPD) banding patterns revealed that *padi angin* is genetically more similar to cultivated rice at the DNA level than wild rice. The results support the hypothesis that *padi angin* was derived from cultivated rice. During periods of low rainfall in the 1980s, dry seeding and volunteer seeding were extensively practised by farmers. The adoption of these methods might have been the main factor contributing to the emergence of *padi angin*.

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Introduction

Where wild relatives of rice having the AA genome are sympatric with cultivated rice they can inter-hybridize. Hybrids between wild and cultivated rice can evolve into weedy types which infest rice fields. This is the probable origin of most weedy rices in deepwater rice areas of countries such as Thailand, Myanmar and Bangladesh (Catling 1992).

In Malaysia, four wild *Oryza* species occur, *O. rufipogon* Griff., *O. officinalis* Wall ex Watt, *O. ridleyi* Hook. and *O. meyeriana* (Zoll. et Morex Steud.) Baill. (Abdullah et al. 1991). Of these species, only *O. rufipogon* has the same genome as cultivated rice and can readily intercross under natural conditions. *O. rufipogon* is sympatric with rice in Kedah, Kelantan, Seberang Perai and Terengganu *(Figure 1)* and can be found growing adjacent to and sometimes in rice fields *(Figure 2)*. Wahab and Suhaimi (1991) first reported *padi angin* or weedy rice from fields around Tanjung Karang, in Projek Barat Laut Selangor (PBLS). Subsequently, the same weed was reported from the Muda area (Mohammed Zuki and Kamarudin 1994). *Padi angin* has considerable morphological diversity (Watanabe 1995) and it was unclear whether it was the product of hybridization between rice and wild rice or it had evolved from cultivated rice.

The objective of this study was to determine the origin of *padi angin*. Variation at the DNA level in wild, *padi angin* and cultivated rices were studied to determine their genetic relationship.

Materials and methods

Seven samples of wild rice, *O. rufipogon*, from the Muda area, nine rice varieties

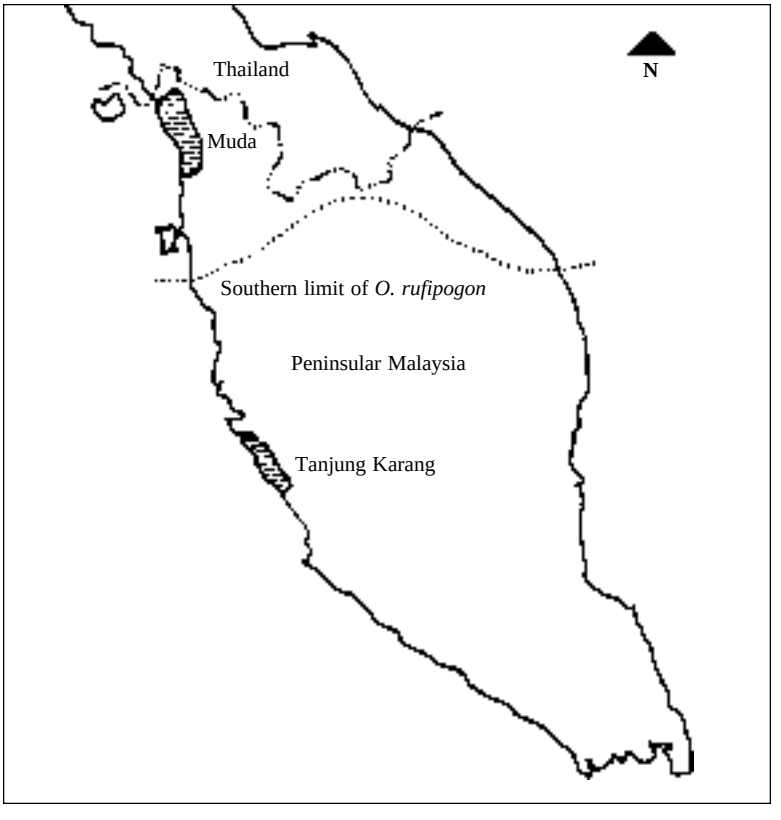

Figure 1. Location of the two main rice-growing areas of Peninsular Malaysia

Figure 2. ***Oryza rufipogon*** *invading a rice field at Kg. Padang Gelam in the Muda irrigation scheme*

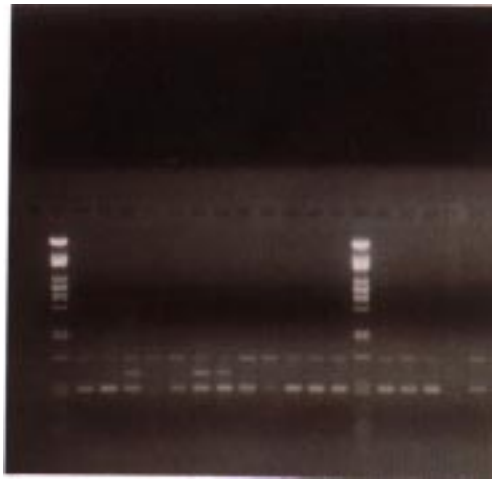

Figure 3. Bands produced by 10-bp primer no. 104 on samples of wild rice (lanes 2–8) and cultivated rice (lanes 9–13, 15–17). Lanes 1 and 14 Lambda-Pst 1 molecular marker

which have been widely grown over the last decade in Peninsular Malaysia (supplied by the MARDI rice genebank) and 28 samples of *padi angin* of which 24 were from a transect across a single infested monitoring field in the Muda area (near Alor Setar) were used. Samples from the field were collected in early 1994.

The base of young tillers were sampled approximately 50 days after planting in the quarantine greenhouse of the National Institute of Agrobiological Resources (NIAR), Tsukuba, Japan. DNA was extracted using the standard method for small-scale extraction of DNA (Williams et al. 1993). The details of polymerase chain reaction (PCR) method have previously been given (Vaughan et al. 1994). Amplification of DNA was performed on a Techne thermal cycler (Techne Inc., Princeton, New Jersey) as described previously (Vaughan, Watanabe et al. 1996). Amplified products after electrophoresis on 1.6% agarose gels containing ethidium bromide were visualized over an ultra-violet light source *(Figure 3)*. Binary data (presence and absence) of RAPD (randomized amplified polymorphic DNA) bands which showed clear polymorphism were analysed using Clustan software (Clustan Ltd., U. K.). Wards coefficient of similarity (Wards 1963) was measured.

Results and discussion

Out of 40 primers, 13 gave clear polymorphic bands for the samples used in this experiment *(Table 1)*. These 13 primers generated 23 clear polymorphic bands which were scored for band presence (1) and absence (0). Analysis of the binary data is presented as a dendrogram in *Figure 4.* The results show two distinct clusters. One cluster consists of all the wild rice samples with one exception. The second cluster consists of *padi angin* and cultivated rice and one sample of wild rice. These results suggest *padi angin* is much more similar to cultivated rice than wild rice.

The single sample of wild rice which fell in the *padi angin*/cultivated rice cluster is a rather unusual population which grows near Alor Setar. This population, unlike other samples, flowers in August and thus it is either insensitive or only weakly sensitive to photoperiod. The results suggest that this particular wild rice sample, which is highly heterogeneous based on a population study

Table 1. Constitution of selected primers and number of polymorphic bands exhibited by each group of samples

Primer no.	Nucleotide sequence	*Oryza rufipogon*	Weedy rice	Cultivated rice	Total no. of polymorphic bands
4	GCAGAGCATC	3	0	1	3
7	AGCACTTCGC	3	2	2	3
9	ACTCCGCAGT	1	1	1	1
22	ATGAGTCCAC	2	2	2	2
29	TGCGGTCAAC	1	1	1	1
34	CTTGCCTCCC	1	1	1	1
41	GAGTGCGCAG	2	0	0	2
42	CCGGACTGAG	2	2	1	2
104	TGGTCCCTGA	1	1	1	2
105	TGGTCGCTGA	1	0	0	1
108	TGGACACTGA	1	1	2	2
110	TGGGCACTGA	1	0	0	1
117	TGGTCAGTGA	2	1	0	2
	Total	21	12	12	23

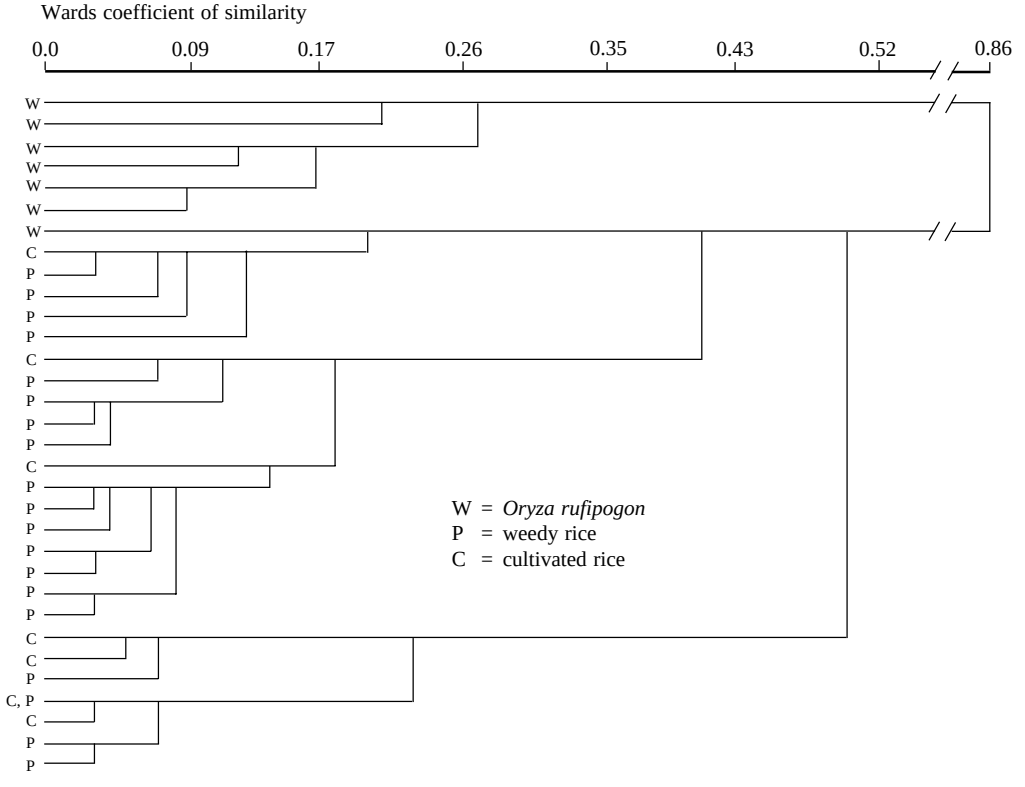

Figure 4. Cluster analysis of DNA banding patterns revealed by RAPD analysis of wild, weedy and cultivated rice from the Muda area

we have conducted (Vaughan, Abdullah et al. 1996), may be a hybrid population between *O. rufipogon* and cultivated rice with the population retaining most of its wild characteristics.

The dendrogram clearly suggests that *padi angin* evolved from the cultigen rather than wild rice. Most *padi angin* in the Muda area and PBLS have morphological characteristics which are more similar to the cultigen than wild rice (Watanabe 1995). *Padi angin* could not have evolved from wild rice in PBLS where *O. rufipogon* has not been reported *(Figure 1)*. However, *padi angin* could have been brought into this rice-growing area from elsewhere. A possible route might have involved combine harvestors which move between rice-growing areas in Malaysia (Azmi et al. 1994). However, *padi angin* was first reported from Tanjung Karang (Wahab and Suhaimi 1991) so this possibility appears unlikely. In the Muda area, *O. rufipogon* is common and this species grows in and around rice fields *(Figure 2)*. However, introgression can be seen in other parts of Asia has not been observed in the Muda area by the authors. One reason why introgression of wild genes into rice may be uncommon in the Muda area is that the flowering time of wild rice does not coincide with that of cultivated rice.

Consequently, since our results support the hypothesis that *padi angin* arose from cultivated rice, how could this have occurred and apparently within a short period of time in two different areas? One explanation may be the practice of dry seeding and volunteer seeding. Volunteer seeding is the use of dropped seed from cultivated rice to establish the next season crop. Malaysian cultivars tend to have moderate to easy threshability, and dropped seed at harvest time are common. In the subsequent season, germinated dropped seed are supplemented by seed broadcast by the farmer in empty patches in the field. This practice would rapidly lead to the selection of more easily shattering types. Spontaneous shattering types of weedy rice such as *padi angin* which are genetically quite similar to the cultigen, may have evolved in this way.

Data on the practice of volunteer seeding is available for the Muda area, but not in PBLS. In the dry years of 1984 and 1987, volunteer seeding was practised on 53% and 40% of the Muda rice area during the off (dry) season (Ho 1991).

Between 1984 and 1988, more than 10 000 ha of land were volunteer-seeded during the off season. It seems likely that during these years shattering ecotypes of rice evolved and became recognized in the early 1990s as *padi angin*. Farmers in the Muda and PBLS areas are now advised not to practise volunteer seeding. However, *padi angin* infestation remains a problem in some areas, particularly where water supply and control is inadequate. Recent reports of shattering types which 'closely resemble' the popular variety MR 84 in Tanjung Karang (Vaughan, Watanabe et al. 1996), suggest that *padi angin* may remain a problem for some time since hand-weeding to remove close 'mimics' of the cultivated crop will be very difficult.

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