

CHAPTER IV

RESULTS

4.1 Genetic diversity of common wild rice populations in Cambodia.

4.1.1 Survey of common wild rice

Ten populations were found and collected from Phnom Penh (3 populations), Kandal (1), Takeo (2), and Prey Veng (4) (Table 4.1). According to locations, populations from Phnom Penh and Kandal were much closed. Therefore, they were grouped in the same region (Figure 3.1). The samples then classified into three regions Phnom Penh (PP1-PP3) plus Kandal (KD), Takeo (TK1 and TK2) and Prey Veng (PV1-PV4) (Table 4.1).

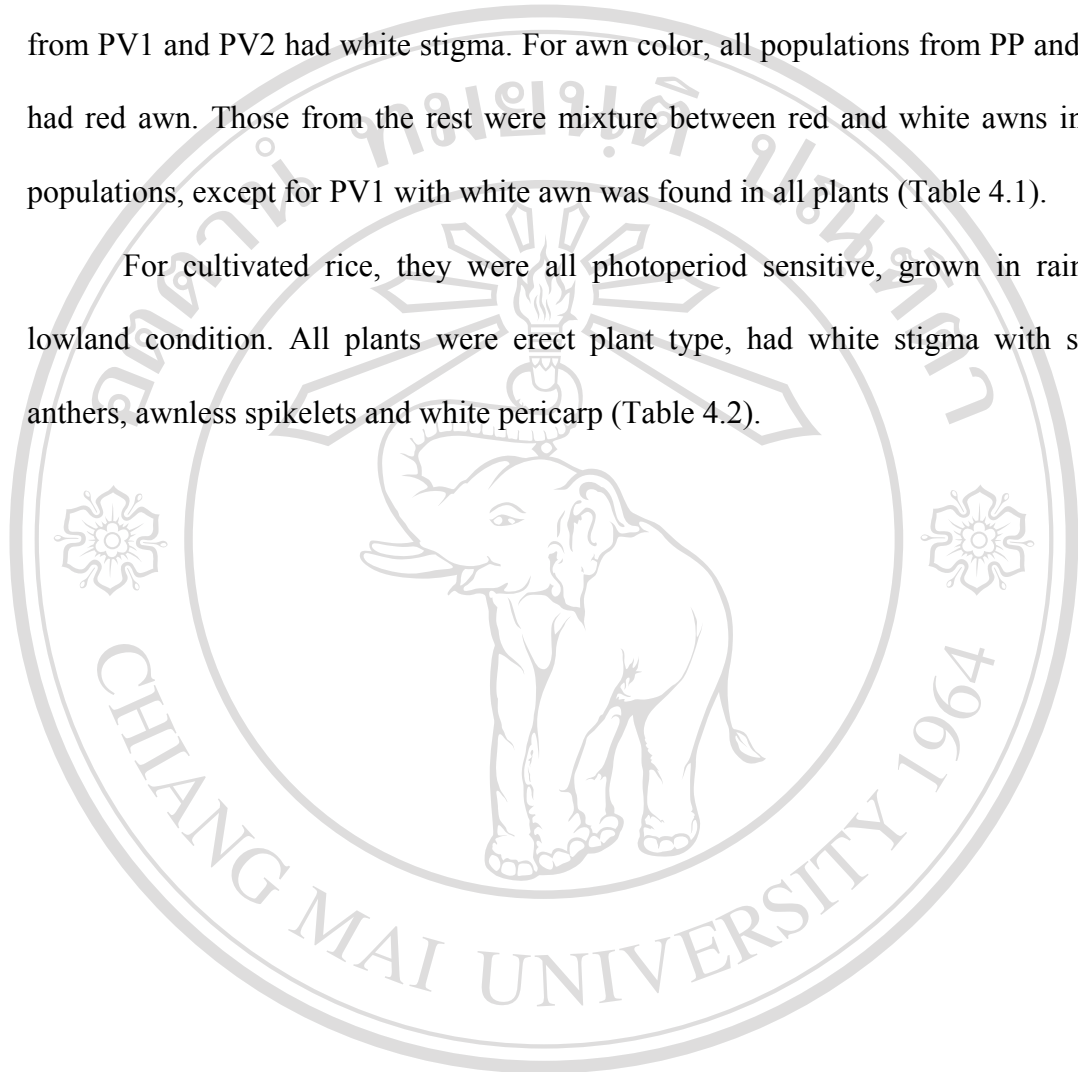
In common wild rice populations collected from Phnom Penh (PP1-PP3) plus Kandal (KD), They were found in road-side ditches, abandoned field and edge rice field, covered about 1000-2000 m². Populations were identified as perennial type for PP1, annual for PP3 and intermediate between annual and perennial PP2 and KD.

Two populations (perennial TK1 and intermediate TK2 types) collected from Takeo were both found in abandoned field in the areas ranged from 300-1050 m². In Prey Veng, four populations with two each of perennial (PV1 and PV2) and annual (PV3 and PV4) types were found in abandoned fields, canal, or road-side ditch and the cover area ranged from 1000-3000m² (Table 4.1).

For morphological characteristics, all plants had open plant type, long awn with black-straw hull (Table 4.1). At the time of survey, plants were at anthesis with three plants from TK1 were at milking stage. Most of them exhibited small anthers

(about half of the spikelet) with only two perennial populations (PV1 and PV2) had all plants with large anthers. All but three plants showed purple stigma, three plants from PV1 and PV2 had white stigma. For awn color, all populations from PP and KD had red awn. Those from the rest were mixture between red and white awns in the populations, except for PV1 with white awn was found in all plants (Table 4.1).

For cultivated rice, they were all photoperiod sensitive, grown in rainfed, lowland condition. All plants were erect plant type, had white stigma with small anthers, awnless spikelets and white pericarp (Table 4.2).



ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่
Copyright© by Chiang Mai University
All rights reserved

Table 4.1 Ecotype, habitat, and morphological character at anthesis of 10 common wild rice populations survey in Cambodia

Pop.	Indi.	Ecotype	Habitat	Area (m ²)	Area		Plant type		Anther length		
					patchy	all covered	erect	open	½	¾	same spikelet
PP1	10	Perennial	Road-side ditch	1000	-	10	-	10	10	-	-
PP2	10	Intermediate	Road-side ditch	1500	-	10	-	10	10	-	-
PP3	10	Annual	Abandoned field	1000	10	-	-	10	10	-	-
KD	10	Intermediate	Edge rice field	2000	10	-	-	10	10	-	-
TK1	10	Perennial	Abandoned field	300	10	-	-	10	10	-	-
TK2	10	Intermediate	Abandoned field	1050	10	-	-	10	10	-	-
PV1	10	Perennial	Canal	1000	-	10	-	10	-	-	10
PV2	10	Perennial	Road-side ditch	1500	10	-	-	10	-	-	10
PV3	10	Annual	Abandoned field	2500	-	10	-	10	10	-	-
PV4	10	Annual	Abandoned field	3000	10	-	-	10	10	-	-

PP = Phnom Penh, KD = Kandal, TK = Takeo

½ = ½ of spikelet, ¾ = ¾ of spikelet

Table 4.1 (Continued).

Pop.	Indi.	Growth stage		Stigma color		Awn color		Awn length		Hull color		
		anthesis	milking	white	purple	red	white	0-5cm	5-10cm	black	black-straw	straw
PP1	10	10	-	-	10	10	-	-	10	-	10	-
PP2	10	10	-	-	10	10	-	-	10	-	10	-
PP3	10	10	-	-	10	10	-	-	10	-	10	-
KD	10	10	-	-	10	10	-	-	10	-	10	-
TK1	10	7	3	-	10	2	8	-	10	-	10	-
TK2	10	10	-	-	10	5	5	-	10	-	10	-
PV1	10	10	-	2	8	-	10	-	10	-	10	-
PV2	10	10	-	1	9	8	2	-	10	-	10	-
PV3	10	10	-	-	10	9	1	-	10	-	10	-
PV4	10	10	-	-	10	10	-	-	10	-	10	-

PP = Phnom Penh, KD = Kandal, TK = Takeo

Copyright© by Chiang Mai University
All rights reserved

Table 4.2 Ecotype, habitat, and morphological character of 7 cultivated rice survey in Cambodia

Cultivar	Plants	Location	Habitat	Sensitivity	Plant type	Stigma color	Anther length	Awn	Pericarp color
ChP	5	Phnom Penh	Rainfed lowland	Yes	All erect	All white	All ½ of spikelet	All awnless	All white
SK	5	Phnom Penh	Rainfed lowland	Yes	All erect	All white	All ½ of spikelet	All awnless	All white
PhK	5	Phnom Penh	Rainfed lowland	Yes	All erect	All white	All ½ of spikelet	All awnless	All white
ChR	5	Takeo	Rainfed lowland	Yes	All erect	All white	All ½ of spikelet	All awnless	All white
SA	5	Takeo	Rainfed lowland	Yes	All erect	All white	All ½ of spikelet	All awnless	All white
Mrom	5	Prey Veng	Rainfed lowland	Yes	All erect	All white	All ½ of spikelet	All awnless	All white
MM	5	Prey Veng	Rainfed lowland	Yes	All erect	All white	All ½ of spikelet	All awnless	All white

ChP = Chhmar Prom, SK = Srau Krahorn, PhK = Phkar Khgney, ChR = Chomkoum Rumpak, SA = Sombok Angkrorng, MM = Mong Mang.



(A)



(B)



(C)

Fig.4.1 Views of habitat of common wild rice populations collected in Oct.16-25, 2007.

4.1.2 Genetic structure of common wild rice population

Distribution of alleles of five microsatellite loci

Common wild rice and local rice are genetically variable at all five microsatellite loci. Table 4.3 showed that the number of alleles varied by locus ranged from 4-7 with the maximum was found in RM20 (7 alleles), followed by RM164 and RM225 (6 alleles), RM341 (5 alleles) and the minimum was found 4 alleles in RM588 and total average of 5 microsatellite loci was 28 alleles. Some samples were polymorphic for 5 loci whereas other samples contained only one locus (except ChP, PhK, and ChR were monomorphic for a single allele at each locus). A total of 132 alleles detected in five microsatellite loci in 100 individuals from 10 common wild rice populations and 41 alleles detected in 35 individuals from 7 samples local rice varieties of four locations in Cambodia.

Table 4.3 Number of alleles samples of 10 common wild rice populations and 7 local rice varieties collected from different province, based on five microsatellite loci.

Genotype	Source	RM20	RM164	RM225	RM341	RM588	Total
Wild rice							
PP 1	Phnom Penh	4	3	3	2	2	14
PP 2	Phnom Penh	2	4	3	2	1	12
PP 3	Phnom Penh	6	3	3	3	3	18
KD	Kandal	2	3	3	2	2	12
TK 1	Takeo	3	5	3	4	3	18
TK2	Takeo	4	3	2	2	2	13
PV 1	Prey Veng	1	1	2	1	4	9
PV 2	Prey Veng	2	2	2	3	3	12
PV 3	Prey Veng	3	4	2	1	2	12
PV 4	Prey Veng	3	2	3	2	2	12
Total							132
Cultivated							
ChP	Phnom Penh	1	1	1	1	1	5
SK	Phnom Penh	1	2	1	2	1	7
PhK	Phnom Penh	1	1	1	1	1	5
ChR	Takeo	1	1	1	1	1	5
SA	Takeo	1	2	1	2	1	7
Mrom	Prey Veng	1	1	1	2	1	6
MM	Prey Veng	1	2	1	1	1	6
Total							41
Average		7	6	6	5	4	28

PP = Phnom Penh, KD = Kandal, TK = Takeo, PV = Prey Veng, ChP = Chhmar Prom, SK = Srau Krahom, PhK = Phkar Khgney, ChR = Chomkoum Rumpak, SA = Sombok Angkroeng, MM = Mong Mang.

Distribution of allele frequency of cultivated rice and wild rice populations

DNA of cultivated rice and wild rice samples were analyzed using five markers (RM20, RM164, RM225, RM341, and RM588), the distribution of each primer were found as followed:

RM20

Seven allele types were found in RM20, A B C D E F and G (Table 4.4). Allele D was found in all 7 cultivated rice varieties and wild rice from PP, KD and TK but not in those from PV. Allele A was found in all plants of PV1 and a few in PP1 and PP3. Allele B and C were common in most wild rice from all three regions. E allele was shown in PV3 and PV4 at the frequencies of 0.4 and 0.5, respectively. F and G alleles were found in only or two plants of PP1 and PP3

RM164

Six allele types were found in RM164, A B C D E and F (Table 4.5). One cultivated rice (ChP) was fixed for A and three (PhK, ChR, and Mrom) for E alleles. The other three varieties were mixture between plants with A or E allele. For wild rice, all allele types were found in populations from PP and KD. Allele F was not found in TK and C and D not found in PV populations.

RM225

Six allele types, A B C D E and F were found in this primer (Table 4.6). All cultivated rice varieties were fixed for F allele (1.0) while no wild rice plant contained this allele. Allele A was found in all wild rice populations except TK2. Apart from A, most wild rice contained B, C or D allele except PV3, which only E at 0.6 was found in this population.

RM341

Five allele types were found in RM341, A B C D and E (Table 4.7). One cultivated rice (ChR) was fixed for A and three (ChP, PhK and MM) for E alleles. The other three varieties were mixture between plants with A or E allele. For wild rice, most plants in PP, KD, TK except TK2 had A and D allele. For populations from PV, only A, B and C alleles were found. Only one plant from KD with E allele was found.

RM588

Four allele types were found in RM588, A B C D (Table 4.8). All cultivated rice varieties were fixed for D allele while some plants from PV contained this allele. Allele A and B were found in most wild rice populations. Allele C was found in all PV populations and some plants in PP3 and TK1. Only PV2 and PV3 had D allele as found in cultivated rice.

Table 4.4 Allele frequencies of 7 local rice varieties and 10 wild rice populations collected from four locations in Cambodia based on microsatellite marker (RM 20).

Genotype	Source	Allele						
		A	B	C	D	E	F	G
Wild rice								
PP 1	Phnom Penh	0.20	0	0.20	0.30	0	0.30	0
PP 2	Phnom Penh	0	0.80	0	0.20	0	0	0
PP 3	Phnom Penh	0.10	0.10	0.20	0.30	0	0.20	0.10
KD	Kandal	0	0	0.10	0.90	0	0	0
TK 1	Takeo	0	0	0.40	0.50	0.10	0	0
TK2	Takeo	0.10	0.50	0	0.30	0.10	0	0
PV 1	Prey Veng	1.00	0	0	0	0	0	0
PV 2	Prey Veng	0	0.50	0.50	0	0	0	0
PV 3	Prey Veng	0	0.50	0.10	0	0.40	0	0
PV 4	Prey Veng	0	0.20	0.30	0	0.50	0	0
Cultivated rice								
ChP	Phnom Penh	0	0	0	1.00	0	0	0
SK	Phnom Penh	0	0	0	1.00	0	0	0
PhK	Phnom Penh	0	0	0	1.00	0	0	0
ChR	Takeo	0	0	0	1.00	0	0	0
SA	Takeo	0	0	0	1.00	0	0	0
Mrom	Prey Veng	0	0	0	1.00	0	0	0
MM	Prey Veng	0	0	0	1.00	0	0	0

PP = Phnom Penh, KD = Kandal, TK = Takeo, PV = Prey Veng, ChP = Chhmar

Prom, SK = Srau Krahorn, PhK = Phkar Khgney, ChR = Chomkoum Rumpak, SA = Sombok Angkrorng, MM = Mong Mang.

Table 4.5 Allele frequencies of 7 local rice varieties and 10 wild rice populations collected from four locations in Cambodia based on microsatellite marker (RM 164).

Genotype	Source	Allele					
		A	B	C	D	E	F
Wild rice							
PP 1	Phnom Penh	0.50	0	0	0.10	0.40	0
PP 2	Phnom Penh	0.10	0	0.50	0.30	0	0.10
PP 3	Phnom Penh	0.60	0	0.10	0.30	0	0
KD	Kandal	0	0.40	0.30	0	0	0.30
TK 1	Takeo	0.10	0.10	0.10	0.40	0.30	0
TK2	Takeo	0.40	0.40	0	0	0.20	0
PV 1	Prey Veng	1.00	0	0	0	0	0
PV 2	Prey Veng	0.25	0.75	0	0	0	0
PV 3	Prey Veng	0.10	0.30	0	0.20	0	0.40
PV 4	Prey Veng	0.50	0	0	0.50	0	0
Cultivated rice							
ChP	Phnom Penh	1.00	0	0	0	0	0
SK	Phnom Penh	0.60	0	0	0	0.40	0
PhK	Phnom Penh	0	0	0	0	1.00	0
ChR	Takeo	0	0	0	0	1.00	0
SA	Takeo	0.90	0	0	0	0.10	0
Mrom	Prey Veng	0	0	0	0	1.00	0
MM	Prey Veng	0.20	0	0	0	0.80	0

PP = Phnom Penh, KD = Kandal, TK = Takeo, PV = Prey Veng, ChP = Chhmar Prom, SK = Srau Krahorng, PhK = Phkar Khgney, ChR = Chomkourmpak, SA = Sombok Angkrong, MM = Mong Mang.

Table 4.6 Allele frequencies of 7 local rice varieties and 10 wild rice populations collected from four locations in Cambodia based on microsatellite marker (RM 225).

Genotype	Source	Allele					
		A	B	C	D	E	F
Wild rice							
PP 1	Phnom Penh	0.40	0	0.50	0.10	0	0
PP 2	Phnom Penh	0.60	0.10	0.30	0	0	0
PP 3	Phnom Penh	0.10	0.80	0.10	0	0	0
KD	Kandal	0.60	0	0.30	0.10	0	0
TK 1	Takeo	0.10	0	0.60	0.30	0	0
TK2	Takeo	0	0	0.20	0.80	0	0
PV 1	Prey Veng	0.10	0.90	0	0	0	0
PV 2	Prey Veng	0.50	0.50	0	0	0	0
PV 3	Prey Veng	0.40	0	0	0	0.60	0
PV 4	Prey Veng	0.70	0	0.10	0.20	0	0
Cultivated rice							
ChP	Phnom Penh	0	0	0	0	0	1.00
SK	Phnom Penh	0	0	0	0	0	1.00
PhK	Phnom Penh	0	0	0	0	0	1.00
ChR	Takeo	0	0	0	0	0	1.00
SA	Takeo	0	0	0	0	0	1.00
Mrom	Prey Veng	0	0	0	0	0	1.00
MM	Prey Veng	0	0	0	0	0	1.00

PP = Phnom Penh, KD = Kandal, TK = Takeo, PV = Prey Veng, ChP = Chhmar Prom, SK = Srau Krahorng, PhK = Phkar Khgney, ChR = Chomkum Rumpak, SA = Sombok Angkrong, MM = Mong Mang.

Table 4.7 Allele frequencies of 7 local rice varieties and 10 wild rice populations collected from four locations in Cambodia based on microsatellite marker (RM 341).

Genotype	Source	Allele				
		A	B	C	D	E
Wild rice						
PP 1	Phnom Penh	0.80	0	0.20	0	0
PP 2	Phnom Penh	0.30	0	0	0.70	0
PP 3	Phnom Penh	0.40	0	0.20	0.40	0
KD	Kandal	0	0	0	0.90	0.10
TK 1	Takeo	0.10	0.10	0.65	0.15	0
TK2	Takeo	0.90	0	0	0.10	0
PV 1	Prey Veng	1.00	0	0	0	0
PV 2	Prey Veng	0.25	0.50	0.25	0	0
PV 3	Prey Veng	0	1.00	0	0	0
PV 4	Prey Veng	0	0.05	0.95	0	0
Cultivated rice						
ChP	Phnom Penh	0	0	0	0	1.00
SK	Phnom Penh	0.20	0	0	0	0.80
PhK	Phnom Penh	0	0	0	0	1.00
ChR	Takeo	1.00	0	0	0	0
SA	Takeo	0.10	0	0	0	0.90
Mrom	Prey Veng	0.80	0	0	0	0.20
MM	Prey Veng	0	0	0	0	1.00

PP = Phnom Penh, KD = Kandal, TK = Takeo, PV = Prey Veng, ChP = Chhmar

Prom, SK = Srau Krahorng, PhK = Phkar Khgney, ChR = Chomkour Rumpak, SA =

Sombok Angkrorng, MM = Mong Mang.

All rights reserved

Table 4.8 Allele frequencies of 7 local rice varieties and 10 wild rice populations collected from four locations in Cambodia based on microsatellite marker (RM 588).

Genotype	Source	Allele			
		A	B	C	D
Wild rice					
PP 1	Phnom Penh	0.80	0.20	0	0
PP 2	Phnom Penh	1.00	0	0	0
PP 3	Phnom Penh	0.15	0.75	0.10	0
KD	Kandal	0.20	0.80	0	0
TK 1	Takeo	0.35	0.45	0.20	0
TK2	Takeo	0.70	0.30	0	0
PV 1	Prey Veng	0.20	0.40	0.30	0.10
PV 2	Prey Veng	0.25	0	0.45	0.30
PV 3	Prey Veng	0	0.10	0.90	0
PV 4	Prey Veng	0	0.30	0.70	0
Cultivated rice					
ChP	Phnom Penh	0	0	0	1.00
SK	Phnom Penh	0	0	0	1.00
PhK	Phnom Penh	0	0	0	1.00
ChR	Takeo	0	0	0	1.00
SA	Takeo	0	0	0	1.00
Mrom	Prey Veng	0	0	0	1.00
MM	Prey Veng	0	0	0	1.00

PP = Phnom Penh, KD = Kandal, TK = Takeo, PV = Prey Veng, ChP = Chhmar Prom, SK = Srau Krahorng, PhK = Phkar Khgney, ChR = Chomkoum Rumpak, SA = Sombok Angkrong, MM = Mong Mang.

All rights reserved

Genetic variation within population

The highest level of effective number of alleles (A_e) was found in Prey Veng (3.37) and slightly different to Phnom Penh plus Kandal (3.27) while the lowest was found in Takeo (2.21). For average number of alleles per locus (N_a), the lowest was found in Takeo (3.40) while Prey Veng and Phnom Penh plus Kandal showed the same level (4.60). The highest expected heterozygosity (H_e) and observed heterozygosity (H_o) were found in Prey Veng province ($H_e = 0.10$ and 0.70), followed by Phnom Penh plus Kandal ($H_e = 0.03$ and 0.67) and Takeo province ($H_e = 0.00$ and 0.50). Very high inbreeding coefficient (F_{IS}) was found in all populations within Takeo (1.00), Phnom Penh plus Kandal (0.94) and Prey Veng (0.79) indicates, all population were more deficient in heterozygote according to the HWE. In addition, the out-crossing (t) rate showed slightly different between Phnom Penh plus Kandal (0.03) and Prey Veng (0.12) while Takeo province have no out-crossing observed (Table 4.9).

Table 4.9 Effective numbers of alleles (A_e), Average number of alleles per locus (N_a), Expected heterozygosity (H_e), Observed heterozygosity (H_o), Inbreeding coefficient (F_{IS}), Out-crossing rate (t) of populations revealed by microsatellite.

Genotype	No of pop.	A_e	N_a	H_e	H_o	F_{IS}	t
Phnom Penh and Kandal							
	PP1	2.31	2.80	0.53	0	1.00	0
	PP2	1.80	2.40	0.40	0	1.00	0
	PP3	1.83	2.40	0.40	0	1.00	0
	KD	2.63	3.60	0.57	0.10	0.83	0.16
		3.27	4.60	0.67	0.03	0.94	0.03
Takeo							
	TK1	1.51	1.80	0.19	0	1.00	0
	TK2	1.99	2.60	0.46	0	1.00	0
		2.21	3.40	0.50	0.00	1.00	0.00
Prey Veng							
	PV1	2.22	2.40	0.56	0.26	0.52	0.31
	PV2	2.60	3.60	0.63	0.12	0.80	0.11
	PV3	1.97	2.40	0.41	0	1.00	0
	PV4	1.86	2.40	0.44	0.02	0.79	0.12
		3.37	4.60	0.70	0.10	0.79	0.12

Genetic differentiation among population

Common wild rice populations in the present study showed moderate to high level of genetic diversity within population (h) ranging from 0.20 in Takao1 to 0.66 in Prey Veng2 (Table 4.10) with 0.48 in average. A total level of genetic differentiation (F_{ST}) was 0.39. For each location, the highest genetic diversity within location (H_T) was found in Prey Veng (0.70) followed by Phnom Penh plus Kandal (0.68) while Takeo showed the lowest (0.51). The degree of genetic differentiation among samples collected from Takeo province was higher ($F_{ST} = 0.49$) than those from other three provinces which were very similar ($F_{ST} = 0.30$ to 0.32).

Genetic relationships

The dendrogram of common wild rice populations relationship was constructed (Figure 4.2) using the UPGMA clustering method based on pairwise genetic differentiation (Table 4.11), for ten populations of Phnom Penh (3), Kandal (1), Takeo (2) and Prey Veng (4). The populations in the present study were separated into two major clusters by geographical location. The first cluster consisted of three populations from Prey Veng province whereas the others included all populations from Phnom Penh, Kandal and Takao provinces which are close together (Figure 3.1). However, one population from Prey Veng was separated into another group.

Table 4.10 Genetic diversity estimated for 10 common wild rice populations in three locations in Cambodia.

Location	No of pop.	Genetic diversity				
		h	H_S	H_T	D_{ST}	F_{ST}
Phnom Penh and Kandal						
	PP1	0.56				
	PP2	0.42				
	PP3	0.43				
	KD	0.60				
			0.50	0.68	0.23	0.32
Takeo						
	TK1	0.20				
	TK2	0.49				
			0.34	0.51	0.33	0.49
Prey Veng						
	PV1	0.57				
	PV2	0.66				
	PV3	0.43				
	PV4	0.46				
			0.53	0.70	0.23	0.30
Between locations						
	3		0.64	0.75	0.16	0.20
Overall						
	10		0.48	0.76	0.30	0.39

Ten plants per population were analysis

h = Nei's (1973) gene diversity

H_S = Average gene diversity within population

H_T = Total gene diversity for all populations

D_{ST} = Gene diversity among population

F_{ST} = Genetic differentiation among population (Nei, 1978)

Table 4.11 Genetic differentiation among (F_{ST}) matrix values determined across five microsatellites loci in ten common wild rice populations in Cambodia.

	PP1	PP2	PP3	KD	TK1	TK2	PV1	PV2	PV3	PV4
PP1										
PP2	0.2776									
PP3	0.2216	0.3486								
KD	0.3846	0.3717	0.2932							
TK1	0.1505	0.3186	0.1846	0.251						
TK2	0.1478	0.3268	0.2948	0.4276	0.2535					
PV1	0.4099	0.634	0.2922	0.6652	0.5213	0.4877				
PV2	0.3104	0.359	0.2699	0.4238	0.2706	0.3277	0.4921			
PV3	0.4738	0.4954	0.4402	0.5209	0.3837	0.4912	0.6557	0.2493		
PV4	0.3633	0.4683	0.3185	0.4823	0.1935	0.4559	0.5976	0.2983	0.3658	

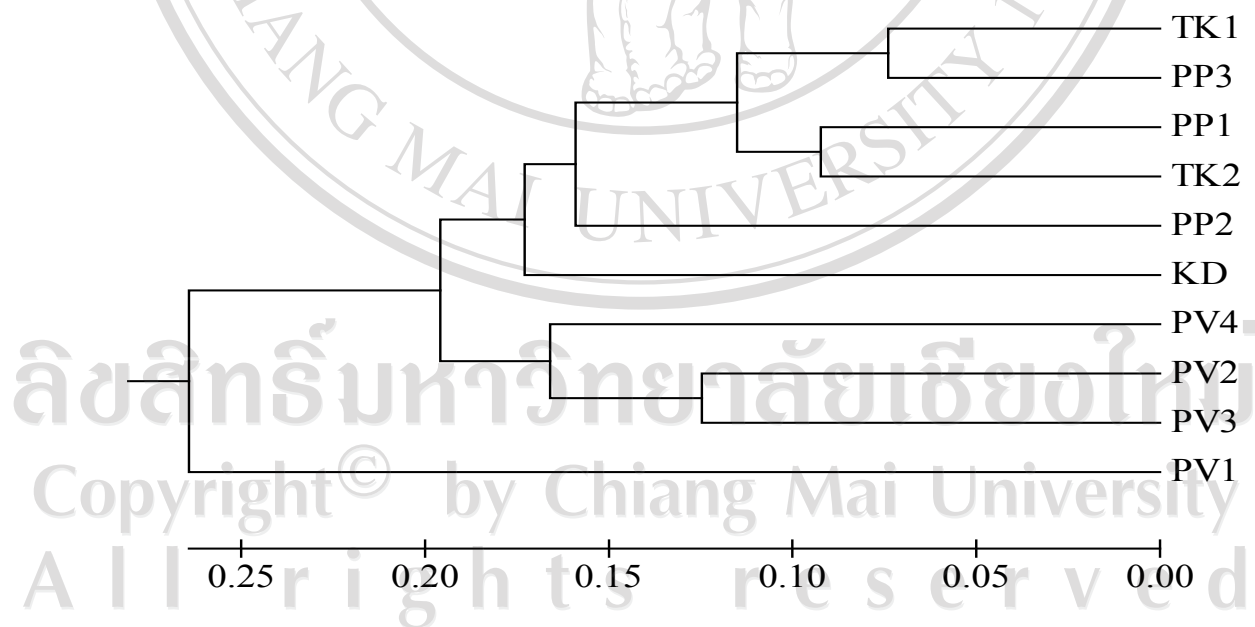


Figure 4.2 A UPGMA dendrogram based on Nei's distance showing genetic relationships among the 10 populations of common wild rice in Cambodia.

Gene flow among cultivated rice and wild rice

Genetic structure of common wild rice populations and cultivated rice were estimated by using STRUCTURE software. Consistent results were obtained when the number of clusters (K) was two (Table 4.12 and Figure 4.3). Wild and cultivated rice were split into different clusters (as shown by red and green colors, respectively, Figure 4.3). Some wild rice plants, ranged from 1 to 7 plants in eight population contained proportion of cultivated rice signatures at 1-5% (Table 4.12). No wild rice membership found in all cultivated rice samples.

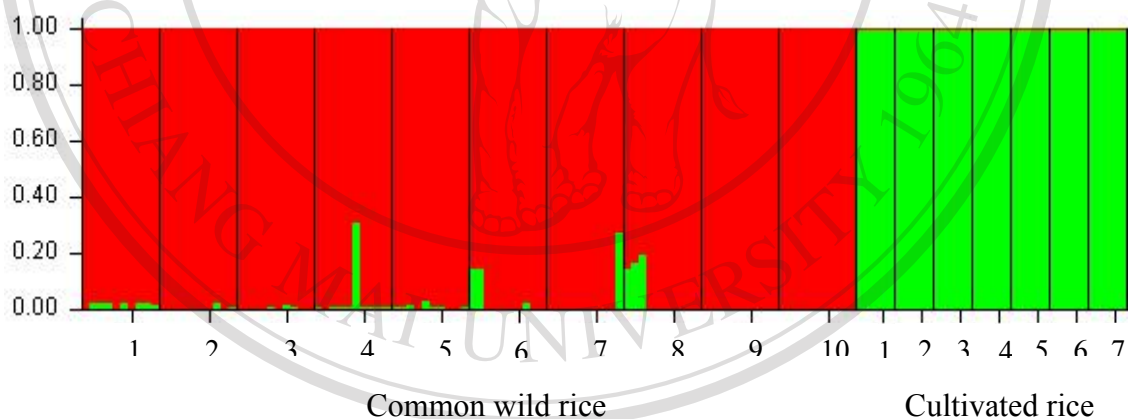


Figure 4.3 Population structures of common wild rice and cultivated rice collected from 4 locations (Phnom Penh, Kandal, Takeo and Prey Veng) of Cambodia was assumed K=2.

Table 4.12 Proportion of inferred cluster (Q) of 7 cultivated rice varieties and 10 common wild rice populations to each inferred population ($K=2$)

Population	Source	n	Given inferred clusters (Q)		
			No. of individual with cultivated rice consanguinity	Wild rice (Q_1)	Cultivated rice (Q_2)
Wild rice					
PP 1	Phnom Penh	10	7	0.983	0.017
PP 2	Phnom Penh	10	1	0.994	0.006
PP 3	Phnom Penh	10	2	0.993	0.007
KD	Kandal	10	1	0.962	0.038
TK 1	Takeo	10	4	0.989	0.011
TK2	Takeo	10	3	0.964	0.036
PV 1	Prey Veng	10	1	0.968	0.032
PV 2	Prey Veng	10	3	0.947	0.053
PV 3	Prey Veng	10	0	0.996	0.004
PV 4	Prey Veng	10	0	0.996	0.004
Cultivated rice					
ChP	Phnom Penh	5	-	0.005	0.995
SK	Phnom Penh	5	-	0.004	0.996
PhK	Phnom Penh	5	-	0.004	0.996
ChR	Takeo	5	-	0.005	0.995
SA	Takeo	5	-	0.005	0.995
Mrom	Prey Veng	5	-	0.005	0.995
MM	Prey Veng	5	-	0.004	0.996

PP = Phnom Penh, KD = Kandal, TK = Takeo, PV = Prey Veng, ChP = Chhmar

Prom, SK = Srau Krahorng, PhK = Phkar Khgney, ChR = Chomkoum Rumpak, SA =

Sombok Angkrorng, MM = Mong Mang.

4.2 Morphological and physiological characteristic of parent and F₂ segregation analysis.

4.2.1 Morphological characterization of plants and seed of F₂ segregation and parents.

Parents

Cultivated rice parents Sen Pidao (SPD) and IR66 showed compact plant and panicle types, green leaf-blade and leaf-sheath, light green auricle and ligule, green internode, straw apiculus and hull color, awnless, and white stigma and pericarp color (Table 4.13).

For wild rice collected from Takeo (TKWR) and Kompong Thom (KTWR), they had open plant and panicle types, green or purple at margin leaf-blade color, purple auricle and internode color, long awn, dark purple stigma color, black-sprite hull color, red pericarp color, except Takeo purple with leaf-sheath and apiculus color and Kompong Thom with light purple and red with leaf-sheath and apiculus color (Table 4.13 cont.).

F₂s

For each characters, both F₂ populations (SPD x TKWR, and IR66 x KTWR) were ranged from the same as cultivated rice to the same as of wild rice parents, consist of compact to open plant and panicle type, green to green purple at margin leaf-blade color, green to intermediate to purple leaf-sheath color, light green to purple auricle color, green to purple internode color, awnless to long awn, white to dark purple stigma color, straw to red to black-sprite hull color, white to red pericarp color, and except crossed between SPD x TKWR, apiculus color with straw to purple and IR66 x KTWR, apiculus color with straw to red (Table 4.13 and Figure 4.4).

Table 4.13: Morphological characteristics of plants and seeds of parents and F₂ segregation population

Crosses	Stem and leaf				Internode color
	Plant type	Leaf-blade color	Leaf-sheath color	Auricle color	
SPD x TKWR					
SPD	compact	green	green	light green	green
TKWR	open	green purple at margin	purple	purple	purple
F ₂	compact-open	green, green purple at margin	green, intermediate, purple	light green, purple	green, purple
IR66 x KTWR					
IR66	compact	green	green	light green	green
KTWR	open	green purple at margin	light purple	purple	purple
F ₂	compact-open	green, green purple at margin	green, intermediate, purple	light green, purple	green, purple

SPD = Sen Pidao, TKWR = wild rice collected from Takeo, KTWR = wild rice collected from Kompong Thom

Table 4.13: (Continued)

Crosses	Panicle, Spikelet and Seed					
	Panicle type	Apiculus color	Spikelet awning	Stigma color	Hull color	Pericarp color
SPD x TKWR						
SPD	compact	straw	awnless	white	straw	white
TKWR	open	purple	long awn	dark purple	black-sprite	red
F ₂	compact-open	straw - purple	awnless-long awn	white-dark purple	straw, red, black-sprite	white-red
IR66 x KTWR						
IR66	compact	straw	awnless	white	straw	white
KTWR	open	red	long awn	dark purple	black-sprite	red
F ₂	compact-open	straw - red	awnless-long awn	white-dark purple	straw, red, black-sprite	white-red

SPD = Sen Pidao, TKWR = wild rice collected from Takeo, KTWR = wild rice collected from Kompong Thom

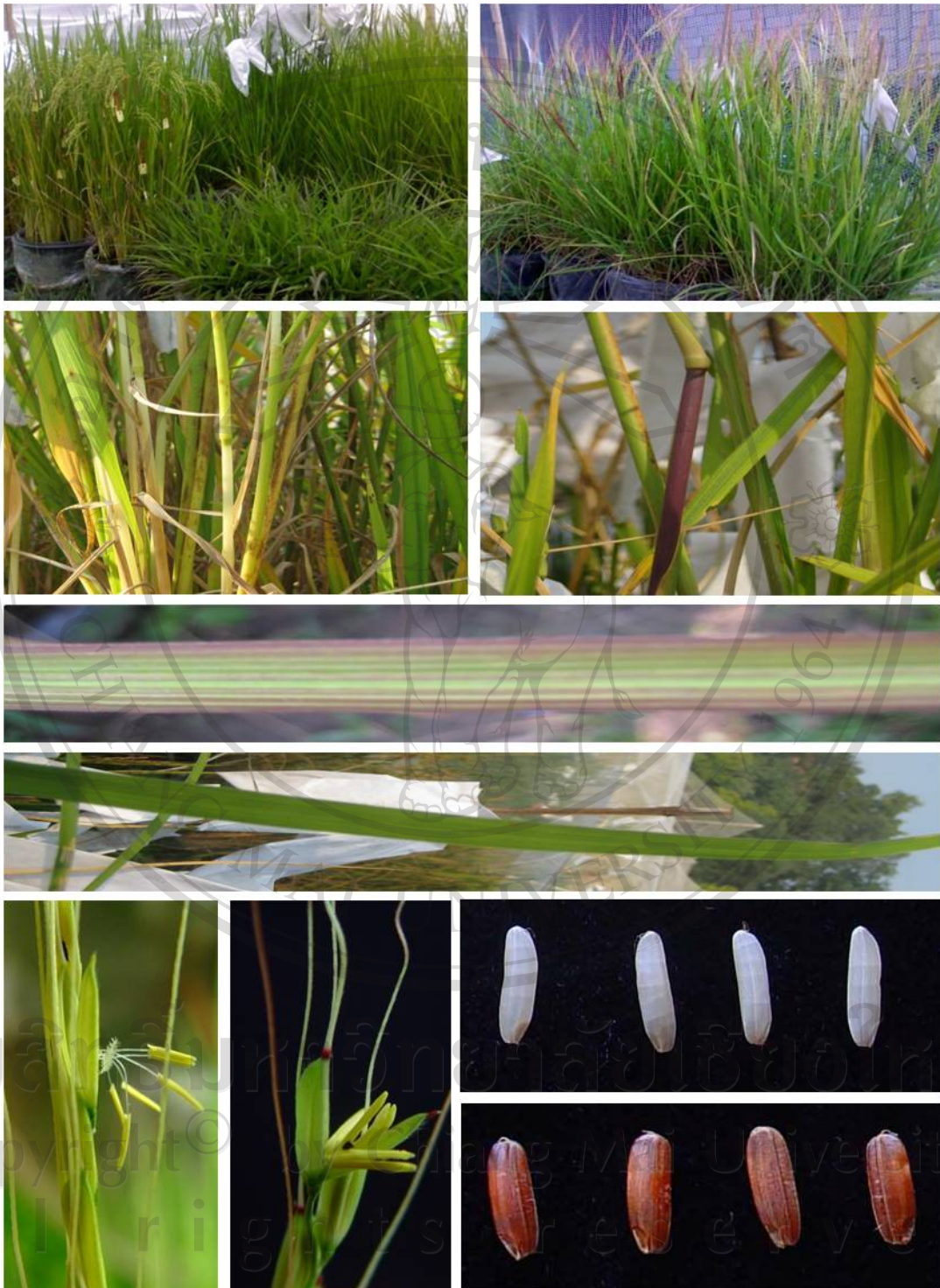


Figure 4.4 Morphological characteristics of plant type, internode color, leaf sheath color, anther length and pericarp color of parent and F_2 segregation population.

4.2.2 Morphological segregation of F₂s

Plant type

Among 200 F₂ plants derived from the cross between IR66 and Kampong Thom wild rice (KTWR), there were 106 plants having compact and 94 plants having intermediate-open. This observation fitted to 9:7 segregation ratios. F₂ populations derived from cross between Sen pidao (SPD) and Takeo wild rice (TKWR) shown 113 plants with compact and 87 plants with intermediate-open were fitted to 9:7 ratio (Table 4.14).

Leaf-blade color

Green and purple at margin leaf blade for both F₂ segregation populations are shown in Table 4.15. Among 200 F₂ plants derived from the cross between IR66 and Kampong Thom wild rice (KTWR), there were 192 plants having green leaf blade and 8 plants having purple at margin leaf blade. This observation fitted to 15:1 segregation ratio. F₂ populations derived from cross between Sen pidao (SPD) and Takeo wild rice (TKWR) shown 158 plants with green and 42 plants with purple at margin leaf blade color and fitted to 3:1 ratio.

Leaf-sheath color

Among 200 F₂ plants of cross between IR66 and Kampong Thom wild rice (KTWR), there were 77 plants having green leaf sheath and 123 plants having light-purple leaf sheath. This observation fitted to 7:9 segregation ratios. F₂ populations derived from cross between Sen pidao (SPD) and Takeo wild rice (TKWR) shown 78 plants with green and 122 plants with light purple-purple leaf sheath color and fitted to same IR66 x KTWR with 7:9 (Table 4.16).

Auricle color

The results of auricle color are presented in Table 4.17, the observation among 200 F₂ plants obtained from IR66 and Kampong Thom wild rice (KTWR), found that, 149 plants with green and 51 plants with purple color fitted to the 3:1 segregation ratios. In contrast, F₂ plants obtained from the cross between Sen pidao and Takeo wild rice (TKWR), fitted to a 9:7 ratio with the observed 115 plants having green and 85 plants having purple.

Ligule color

White and purple ligule color for both F₂ segregation populations are shown in Table 4.18. Among 200 F₂ plants derived from the cross between IR66 and Kampong Thom wild rice (KTWR), there were 111 plants having white and 89 plants having purple, this observation fitted to 9:7 ratios. And F₂ population derived from cross between Sen pidao (SPD) and Takeo wild rice (TKWR) shown 103 plants with white and 97 plants with purple, these fitted to 9:7 segregation ratio.

Internodes color

Among 200 F₂ plants obtained from IR66 and Kampong Thom wild rice (KTWR) was found that, 163 internodes color plants were observed with green and 37 plants with purple line-purple color fitted to the 3:1 segregation ratio. While, F₂ plants obtained from the cross between Sen pidao and Takeo wild rice (TKWR), fitted to a 7:9 ratio with 99 plants having green and 101 plants having purple line and purple color (Table 4.19).

Stigma color

White and red stigma colors were observed in both F₂ segregation populations, IR66 x Kampong Thom wild rice (KTWR) and Sen Pidao (SPD) x Takeo wild rice (TKWR). The result were found that, both F₂ segregation populations were fitted to 1:3 ratio with the white color were found in 40 and 54 plants, and red color were observed 158 and 144 plant, respectively (Table 4.20).

Apiculus color

Straw and red apiculus color for both F₂ segregation populations are shown in Table 4.21. Among 198 F₂ plants derived from the cross between IR66 and Kampong Thom wild rice (KTWR), there were 158 plants having red and 40 plants having straw. For F₂ populations derived from cross between Sen pidao (SPD) and Takeo wild rice (TKWR) observed 144 plants with red and 54 plants with straw apiculus color. Both F₂ segregation populations were fitted to 3:1 segregation ratio.

Awn

The results of awn and awn less are presented in Table 4.22, the observed among 198 F₂ plants obtained from IR66 and Kampong Thom wild rice (KTWR) were found that 193 plants having awn and 5 plants awn less and fitted to the 63:1 segregation ratios. In contrast, F₂ plants obtained from the cross between Sen pidao and Takeo wild rice (TKWR), fitted to a 15:1 ratio with the observed 186 plants having awn and 12 plants having awn less.

Awn color

Red and white awn color for both F₂ segregation populations presented (Table 4.23). Among 193 F₂ plants derived from the cross between IR66 and Kampong Thom wild rice (KTWR), there were 155 plants having red awn and 38 plants having

white awn. And among 186 plants of F₂ populations derived from cross between Sen pidao (SPD) and Takeo wild rice (TKWR) shown 135 plants with red and 51 plants with white awn color, and both F₂ segregation populations were fitted to 3:1 segregation ratio.

Hull color

Straw and black hull color for both F₂ segregation populations are shown in Table 4.24. Among 198 F₂ plants derived from the cross between IR66 and Kampong Thom wild rice (KTWR), there were 139 plants having straw and 59 plants having black, and F₂ populations derived from cross between Sen Pidao (SPD) and Takeo wild rice (TKWR) were found 147 plants with straw and 51 plants with black hull color. 3:1 segregation ratio was fitted to both F₂ segregation populations.

Panicle type

Among 198 F₂ plants obtained from cross between IR66 and Kampong Thom wild rice (KTWR), there were 157 plants having compact and 41 plants having open, fitted to the 3:1 segregation ratio. While, F₂ plants obtained from the cross between Sen pidao and Takeo wild rice (TKWR), fitted to a 9:7 ratio with 108 plants having compact and 90 plants having open (Table 4.25).

Pericarp color

White and red pericarp colors for both F₂ segregation populations were presented (Table 4.26). Among 189 F₂ plants derived from the cross between IR66 and Kampong Thom wild rice (KTWR), there were 43 plants having white pericarp color and 146 plants having red pericarp color. Among 196 plants of F₂ populations derived from cross between Sen pidao (SPD) and Takeo wild rice (TKWR) shown 45

plants with white and 151 plants with red pericarp color. 3:1 segregation ratio was fitted to both F₂ segregation populations.

Table 4.14 Plant type of F₂ populations derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			Compact	Intermediate-open			
IR66 x KTWR	2	Obs.	106	94	9:7	0.86	0.35
		Exp.	112.5	87.5			
SPD x TKWR	2	Obs.	113	87	9:7	0.01	0.94
		Exp.	112.5	87.5			

^aExp. = Expected ratio; Obs. = Observed ratio

Table 4.15 Leaf-blade color of F₂ populations derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			Green	Purple at margin			
IR66 x KTWR	2	Obs.	192	8	15:1	1.73	0.19
		Exp.	187.5	12.5			
SPD x TKWR	1	Obs.	158	42	3:1	1.70	0.19
		Exp.	150	50			

^aExp. = Expected ratio; Obs. = Observed ratio

Table 4.16 Leaf-sheath color of F₂ populations derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			Green	Light-purple			
IR66 x KTWR	2	Obs.	77	123	7:9	2.24	0.14
		Exp.	87.5	112.5			
SPD x TKWR	2	Obs.	78	122	7:9	1.83	0.17
		Exp.	87.5	112.5			

^aExp. = Expected ratio; Obs. = Observed ratio

Table 4.17 Auricle color of F₂ populations derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			Green	Purple			
IR66 x KTWR	1	Obs.	149	51	3:1	0.03	0.87
		Exp.	150	50			
SPD x TKWR	2	Obs.	115	85	9:7	0.13	0.72
		Exp.	112.5	87.5			

^aExp. = Expected ratio; Obs. = Observed ratio

Table 4.18 Ligule color of F₂ populations derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			White	Purple			
IR66 x KTWR	2	Obs.	111	89	9:7	0.05	0.83
		Exp.	112.5	87.5			
SPD x TKWR	2	Obs.	103	97	9:7	1.83	0.18
		Exp.	112.5	87.5			

^aExp. = Expected ratio; Obs. = Observed ratio

Table 4.19 Internodes color of F₂ populations derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			Green	Purple line-purple			
IR66 x KTWR	1	Obs.	163	37	3:1	4.50	0.03
		Exp.	150	50			
SPD x TKWR	2	Obs.	99	101	7:9	2.69	0.10
		Exp.	87.5	112.5			

^aExp. = Expected ratio; Obs. = Observed ratio

Table 4.20 Stigma color of F₂ populations derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			White	Red			
IR66 x KTWR	1	Obs.	40	158	1:3	2.43	0.12
		Exp.	49.5	148.5			
SPD x TKWR	1	Obs.	54	144	1:3	0.55	0.46
		Exp.	49.5	148.5			

^aExp. = Expected ratio; Obs. = Observed ratio

^aExp. = Expected ratio; Obs. = Observed ratio

Table 4.21 Apiculus color of F₂ populations derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			Straw	Red			
IR66 x KTWR	1	Obs.	40	158	1:3	2.43	0.12
		Exp.	49.5	148.5			
SPD x TKWR	1	Obs.	54	144	1:3	0.55	0.46
		Exp.	49.5	148.5			

^aExp. = Expected ratio; Obs. = Observed ratio

Table 4.22 Presentation on awn of F₂ populations derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			Awn	Awnless			
IR66 x KTWR	3	Obs. Exp.	193	5	63:1	1.19	0.27
			194.91	3.09			
SPD x TKWR	2	Obs. Exp.	186	12	15:1	0.01	0.91
			185.63	12.37			

^aExp. = Expected ratio; Obs. = Observed ratio

Table 4.23 Awn color of F₂ population derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			White	Red			
IR66 x KTWR	1	Obs. Exp.	38	155	1:3	2.90	0.09
			48.25	144.75			
SPD x TKWR	1	Obs. Exp.	51	135	1:3	0.58	0.44
			46.5	139.5			

^aExp. = Expected ratio; Obs. = Observed ratio

Table 4.24 Hull color of F₂ populations derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			Straw	Black			
IR66 x KTWR	1	Obs. Exp.	139	59	3:1	2.43	0.12
			148.5	49.5			
SPD x TKWR	1	Obs. Exp.	147	51	3:1	0.06	0.81
			148.5	49.5			

^aExp. = Expected ratio; Obs. = Observed ratio

Table 4.25 Panicle type of F₂ populations derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			Compact	Open			
IR66 xKTWR	1	Obs.	157	41	3:1	1.95	0.16
		Exp.	148.5	49.5			
SPD xTKWR	2	Obs.	108	90	9:7	0.23	0.63
		Exp.	111.38	86.62			

^aExp. = Expected ratio; Obs. = Observed ratio

Table 4.26 Pericarp color of F₂ populations derived from crosses between cultivated and wild rice.

Cross	No. gene	Model ^a	Number of plant		Ratio	χ^2	P
			White	Red			
IR66 x KTWR	1	Obs.	43	146	1:3	0.51	0.48
		Exp.	47.25	141.75			
SPD x TKWR	1	Obs.	45	151	1:3	0.44	0.51
		Exp.	49	147			

^aExp. = Expected ratio; Obs. = Observed ratio

4.2.3 Physiological characteristics of F₂ segregation population analysis

Number of tillers per plant

In general, Takeo (TKWR) and Kompong Thom (KTWR) wild rice parents had higher number of tillers per plant than cultivated rice (SPD and IR66) parents. Mean and SD of the parent were found 6 ± 1 , 7 ± 1 , 29 ± 5 , and 32 ± 7 respectively (Table 4.27). For F₂ populations, the F₂ plants segregated within the range of mean parents (Figure 4.5).

Table 4.27 Range, mean and standard deviation (Sd) of tillers per plant of parents and F₂ populations from crosses between cultivated rice (IR66) x wild rice from Kampong Thom province (KTWR), and Sen pidao (SPD) x wild rice from Takeo province (TKWR).

Crosses	Tillers per plant			
	N	range	mean	sd
Sen Pidao x Takeo wild rice				
- Sen pidao (SPD)	20	5-10	7	1
- Takeo (TKWR)	20	19-43	29	5
- F ₂	200	6-38	20	6
IR66 x Kompong Thom wild rice				
- IR66	20	4-9	6	1
- Kampong Thom province (KTWR)	20	17-45	32	7
- F ₂	200	6-35	18	6

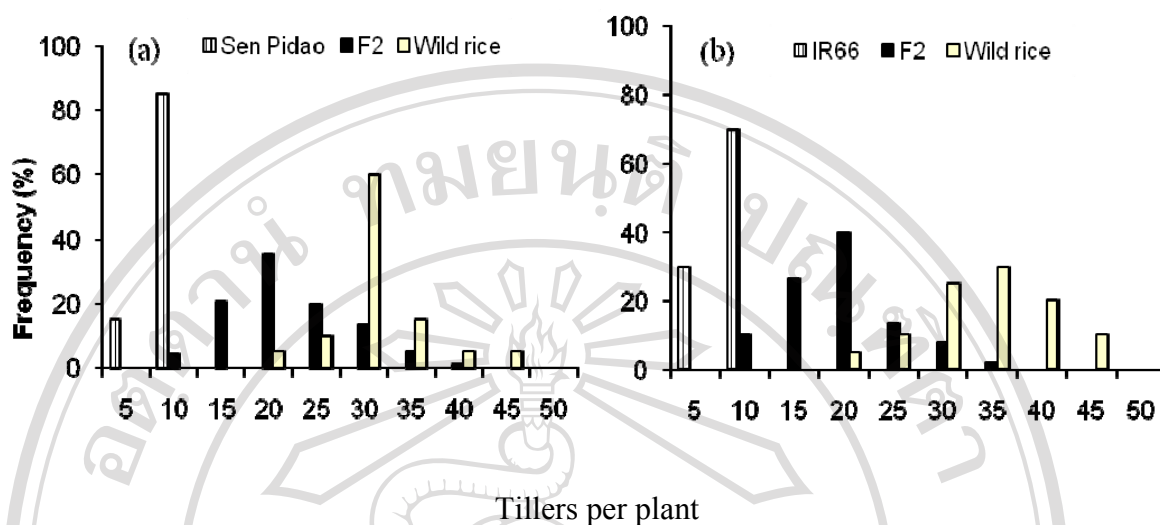


Figure 4.5 Distribution of number of tillers per plant of F₂ populations between Sen pidao (SPD) x wild rice from Takeo province (TKWR) and IR66 x wild rice from Kampong Thom province (KTWR).

(a) SPD x TKWR; mean and SD for SPD, TKWR and F₂s were 7±1, 29±5, and 20±6, respectively.

(b) IR66 x KTWR; mean and SD for IR66, KTWR and F₂s were 6±1, 32±7, and 18±6, respectively.

Plant height

Plant height measured when crop maturity. For the parents, plant height of cultivated rice SPD and IR66 ranged from 55-70cm. Those of wild rice (TKWR) and (KTWR) were ranged from 39-78cm. Transgressive segregations were observed in F₂ from both cross (Table 4.28, Figure 4.6).

Table 4.28 Range, mean and standard deviation (Sd) of plant height (cm) of parents of F₂ populations from crosses between cultivated rice (IR66) x wild rice from Kampong Thom province (KTWR), and Sen pidao (SPD) x wild rice from Takeo province (TKWR).

Crosses	Plant height (cm)			
	N	range	mean	sd
Sen Pidao x Takeo wild rice				
- Sen pidao (SPD)	20	58-70	65	3
- Takeo (TKWR)	20	41-75	61	8
- F ₂	198	26-125	72	19
IR66 x Kompong Thom wild rice				
- IR66	20	55-69	61	4
- Kampong Thom province (KTWR)	20	39-78	58	9
- F ₂	198	23-125	71	18

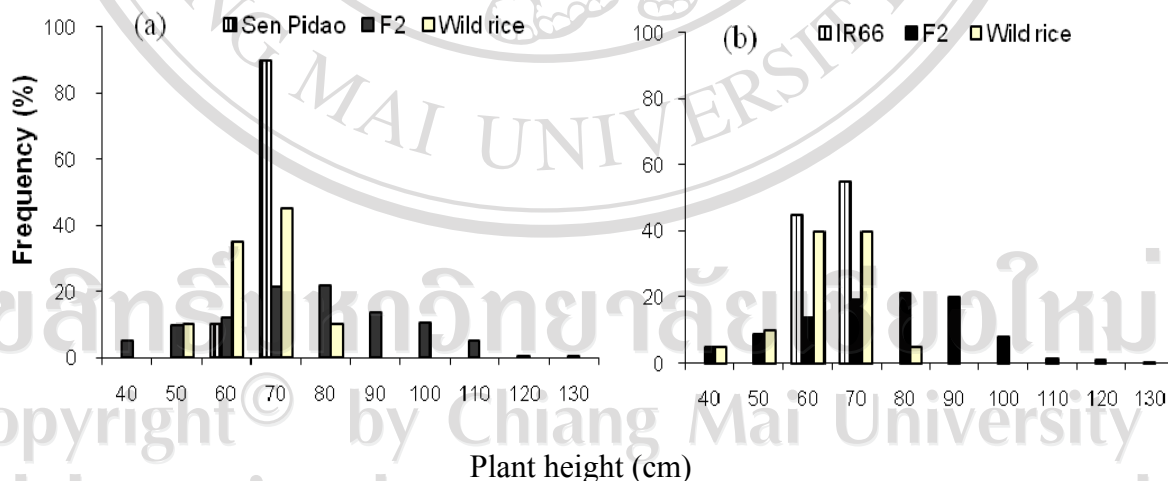


Figure 4.6 Distribution of number of plant height (cm) of F₂ populations between Sen pidao (SPD) x wild rice from Takeo province (TKWR) and IR66 x wild rice from Kampong Thom province (KTWR).

(a) SPD x TKWR; mean and SD for SPD, TKWR and F₂s were 65±3, 61±8, and 72±19, respectively.

(b) IR66 x KTWR; mean and SD for IR66, KTWR and F₂s were 61±4, 58±9, and 71±18, respectively.

Days to flowering

Days to flowering of cultivated rice SPD and IR66 photoperiod insensitive ranged from 67-74days. Those of wild rice Takeo (TKWR) and Kompong Thom (KTWR) ranged from 90-108days (planted date August, 11-2007). Mean and SD of the parent were found 70±2, 72±1, 101±3, and 101±5 respectively (Table 4.29). For F₂ populations, the F₂ plants segregated within the range of parents (Figure 4.7).

Table 4.29 Range, mean and standard deviation (Sd) of days to flowering of parents of F₂ populations from crosses between cultivated rice (IR66) x wild rice from Kampong Thom province (KTWR), and Sen pidao (SPD) x wild rice from Takeo province (TKWR).

Crosses	Days to flowering			
	N	range	mean	sd
Sen Pidao x Takeo wild rice				
- Sen pidao (SPD)	20	67-74	70	2
- Takeo (TKWR)	20	90-108	101	5
- F ₂	199	74-114	91	8
IR66 x Kompong Thom wild rice				
- IR66	20	70-74	72	1
- Kampong Thom province (KTWR)	20	90-108	101	3
- F ₂	198	73-111	91	8

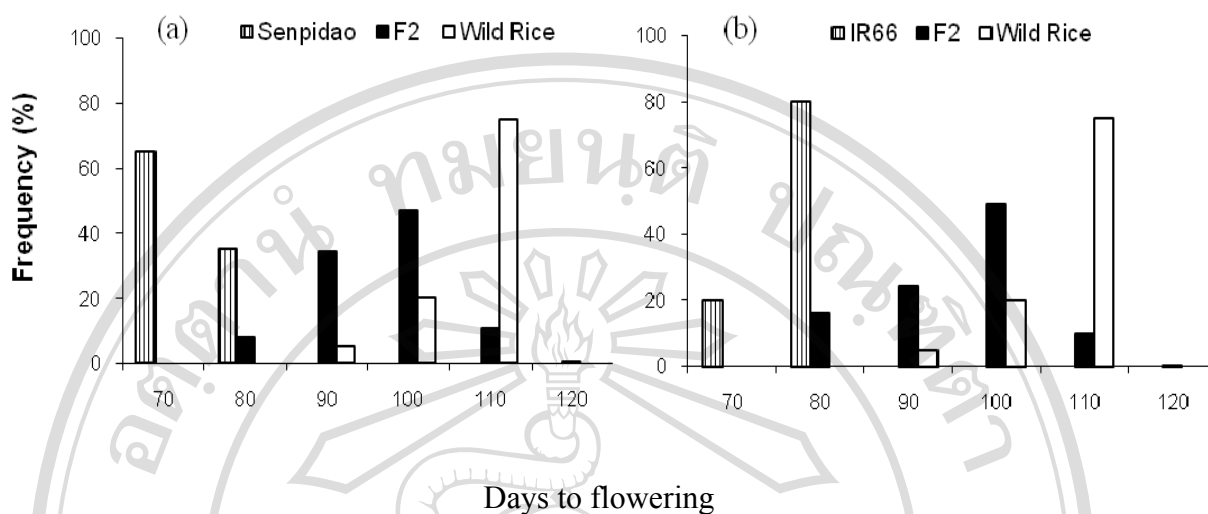


Figure 4.7 Distribution of numbers of days to flowering of F₂ populations between Sen pidao (SPD) x wild rice from Takeo province (TKWR) and IR66 x wild rice from Kampong Thom province (KTWR).

(a) SPD x TKWR; mean and SD for SPD, TKWR and F₂s were 70±2, 101±5, and 91±8, respectively.

(b) IR66 x KTWR; mean and SD for IR66, KTWR and F₂s were 72±1, 101±3, and 91±8, respectively.

Panicle length (cm)

For the parents, panicle length of cultivated rice SPD and IR66 ranged from 17-22cm had higher panicle length than TKWR and KTWR wild rice parent ranged from 11-18cm. Transgressive segregations were observed in F₂ from both cross (Table 4.30, Figure 4.8).

Table 4.30 Range, mean and standard deviation (Sd) of panicle length (cm) of parents of F₂ populations from crosses between cultivated rice (IR66) x wild rice from Kampong Thom province (KTWR), and Sen pidao (SPD) x wild rice from Takeo province (TKWR).

Crosses	Panicle length (cm)			
	N	range	mean	sd
Sen Pidao x Takeo wild rice				
- Sen pidao (SPD)	20	17-22	20	1
- Takeo (TKWR)	40	12-18	15	2
- F ₂	198	12-27	18	3
IR66 x Kompong Thom wild rice				
- IR66	20	17-22	21	1
- Kampong Thom province (KTWR)	40	11-16	14	1
- F ₂	198	11-28	18	3

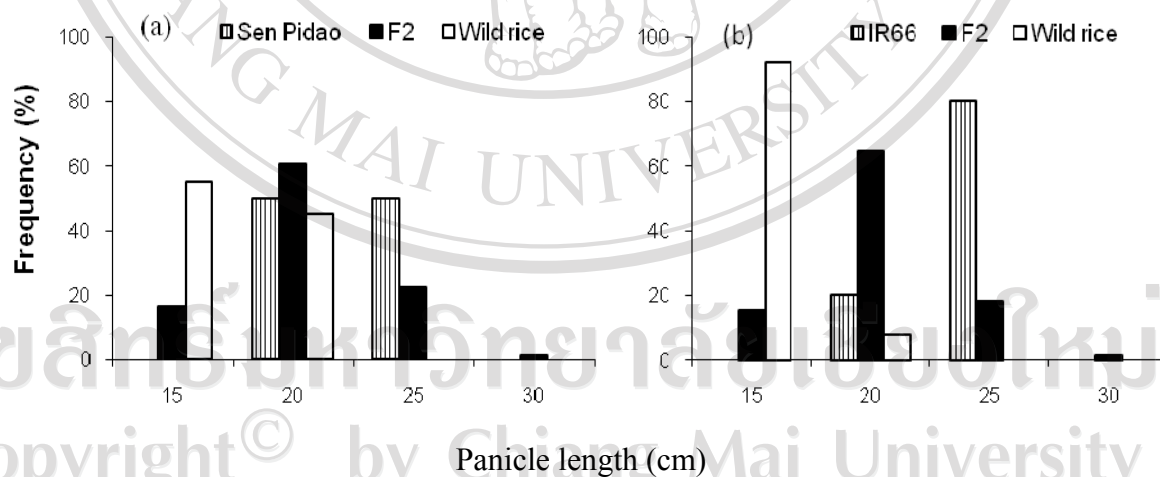


Figure 4.8 Distribution of numbers of panicle length (cm) of F₂ populations between Sen pidao (SPD) x wild rice from Takeo province (TKWR) and IR66 x wild rice from Kampong Thom province (KTWR).

(a) SPD x TKWR; mean and SD for SPD, TKWR and F₂s were 20±1, 15±2, and 18±3, respectively.

(b) IR66 x KTWR; mean and SD for IR66, KTWR and F₂s were 21±1, 14±1, and 18±3, respectively.

Number of branches per panicle

Branches per panicle of SPD and IR66 cultivated rice parent ranged from 6-9 and wild rice parent TKWR and KTWR ranged 4-7. Transgressive segregations were observed in F₂ from both cross (Table 4.31, Figure 4.9).

Table 4.31 Range, mean and standard deviation (Sd) of branches per panicle number of parents of F₂ populations from crosses between cultivated rice (IR66) x wild rice from Kampong Thom province (KTWR) and Sen pidao (SPD) x wild rice from Takeo province (TKWR).

Crosses	Branches per panicle			
	N	range	mean	sd
Sen Pidao x Takeo wild rice				
- Sen pidao (SPD)	20	6-8	7	1
- Takeo (TKWR)	40	4-7	6	1
- F ₂	198	4-13	6	1
IR66 x Kampong Thom wild rice				
- IR66	20	7-9	8	1
- Kampong Thom province (KTWR)	40	4-7	5	1
- F ₂	198	3-10	6	1

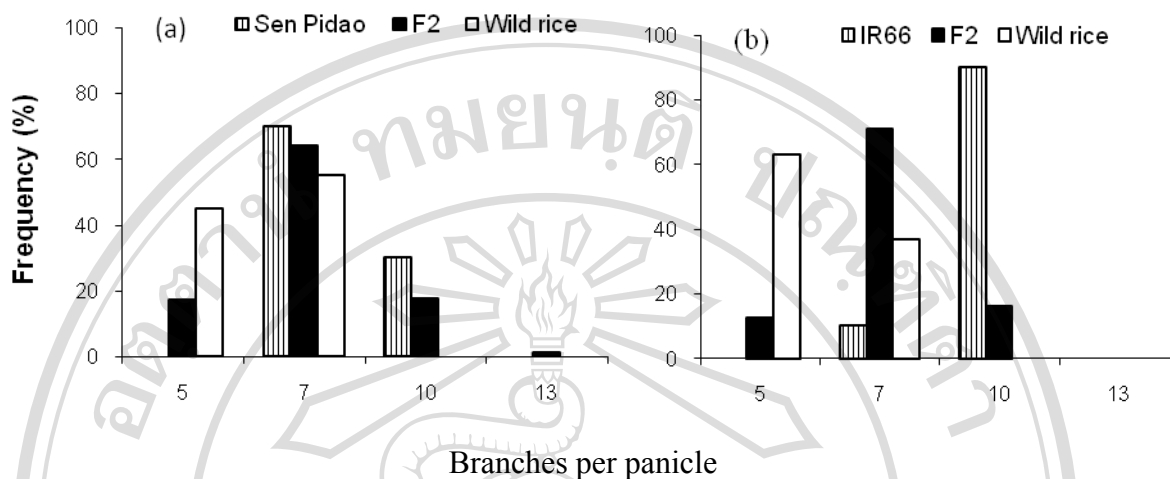


Figure 4.9 Distribution of numbers of branches per panicle of F₂ populations between Sen pidao (SPD) x wild rice from Takeo province (TKWR) and IR66 x wild rice from Kampong Thom province (KTWR).

(a) SPD x TKWR; mean and SD for SPD, TKWR and F₂s were 7±1, 6±1, and 6±1, respectively.

(b) IR66 x KTWR; mean and SD for IR66, KTWR and F₂s were 8±1, 5±1, and 6±1, respectively.

Number of spikelets per panicle

For the parents, number of spikelets per panicle of cultivated rice SPD and IR66 ranged from 62-145 had higher number of spikelets per panicle than TKWR and KTWR wild rice parent ranged from 38-108. Transgressive segregations were observed in F₂ from both cross (Table 4.32, Figure 4.10).

Table 4.32 Range, mean and standard deviation (Sd) of spikelets per panicle of parents of F₂ populations from crosses between cultivated rice (IR66) x wild rice from Kampong Thom province (KTWR), and Sen pidao (SPD) x wild rice from Takeo province (TKWR).

Crosses	Number of spikelets per panicle			
	N	range	mean	sd
Sen Pidao x Takeo wild rice				
- Sen pidao (SPD)	20	66-127	88	17
- Takeo (TKWR)	40	40-108	64	15
- F ₂	198	27-197	75	26
IR66 x Kompong Thom wild rice				
- IR66	20	62-145	111	25
- Kampong Thom province (KTWR)	40	38-74	51	9
- F ₂	198	26-169	73	24

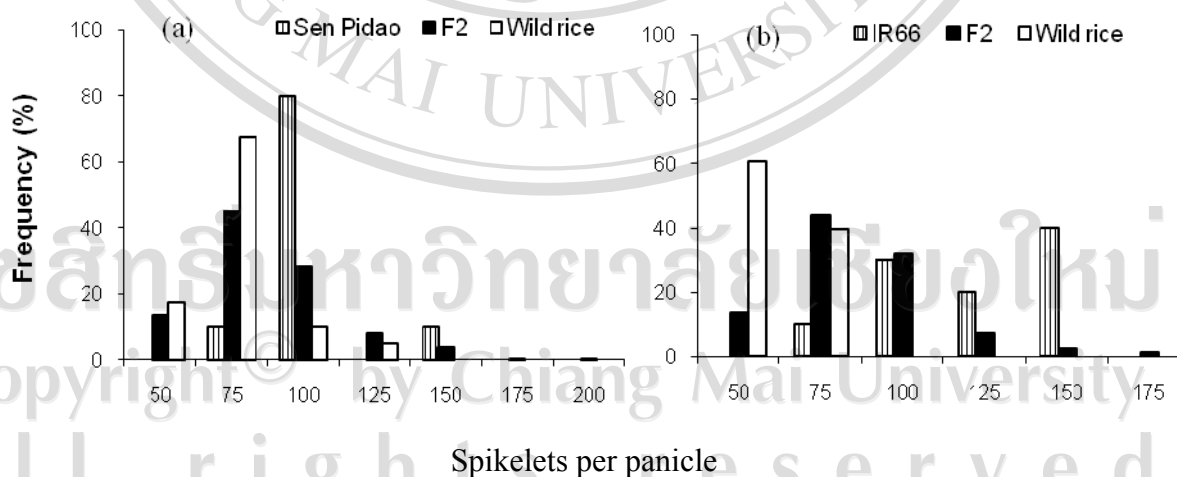


Figure 4.10 Distribution of numbers of spikelets per panicle of F₂ populations between Sen pidao (SPD) x wild rice from Takeo province (TKWR) and IR66 x wild rice from Kampong Thom province (KTWR).

(a) SPD x TKWR; mean and SD for SPD, TKWR and F₂s were 88±17, 64±15, and 75±26, respectively.

(b) IR66 x KTWR; mean and SD for IR66, KTWR and F₂s were 111±25, 51±9, and 73±24, respectively.

Seed fertility (%)

The percent of seed fertility of cultivated rice SPD and IR66 parents ranged from 65-97%., Those of wild rice (TKWR) and (KTWR) were ranged from 50-96% (Table 4.33). For F₂ populations, transgressive segregations were observed in F₂ from both cross (Figure 4.11).

Table 4.33 Range, mean and standard deviation (Sd) of seed fertility (%) of parents of F₂ populations from crosses between cultivated rice (IR66) x wild rice from Kampong Thom province (KTWR), and Sen pidao (SPD) x wild rice from Takeo province (TKWR).

Crosses	Seed fertility (%)			
	N	range	mean	sd
Sen Pidao x Takeo wild rice				
- Sen pidao (SPD)	20	65-88	81	6
- Takeo (TKWR)	40	50-95	77	11
- F ₂	198	0-99	64	18
IR66 x Kompong Thom wild rice				
- IR66	20	87-97	93	3
- Kampong Thom province (KTWR)	40	59-96	79	10
- F ₂	198	0-98	71	15

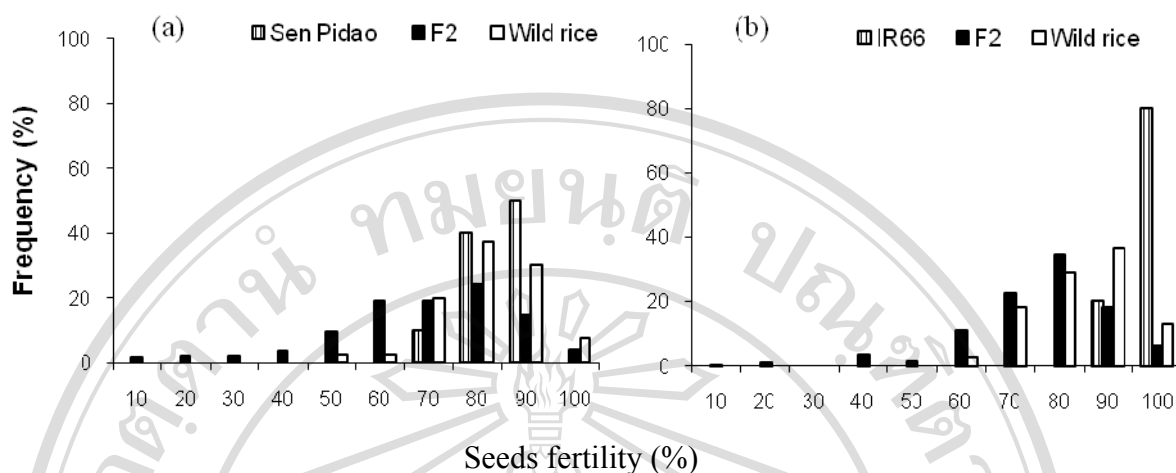


Figure 4.11 Distribution of numbers of seeds fertility (%) of F₂ populations between Sen pidao (SPD) x wild rice from Takeo province (TKWR) and IR66 x wild rice from Kampong Thom province (KTWR).

(a) SPD x TKWR; mean and SD for SPD, TKWR and F₂s were 81%±6, 77%±11, and 64%±18, respectively.

(b) IR66 x KTWR; mean and SD for IR66, KTWR and F₂s were 93%±3, 79%±10, and 71%±15, respectively.

Seed shattering (%)

Percent of seed shattering of cultivated rice SPD and IR66 parents ranged 0-2percent, while TKWR and KTWR wild rice parents were shattered all plants (100%).

The segregation patterns of seed shattering were difference between crosses. The percent of seed shattering derived from SPD x TKWR ranged from 64-100% and

IR66 x KTWR ranged from 2-100% (Table 4.34, Figure 4.12).

Table 4.34 Range, mean and standard deviation (Sd) of seed shattering (%) of parents of F₂ populations from crosses between cultivated rice (IR66) x wild rice from Kampong Thom province (KTWR), and Sen pidao (SPD) x wild rice from Takeo province (TKWR).

Crosses	Seed shattering (%)			
	N	range	mean	sd
Sen Pidao x Takeo wild rice				
- Sen pidao (SPD)	20	0-2	1	1
- Takeo (TKWR)	40	100	100	0
- F ₂	196	64-100	99	6
IR66 x Kompong Thom wild rice				
- IR66	20	0-2	0	1
- Kampong Thom province (KTWR)	40	100	100	0
- F ₂	176	2-100	83	25

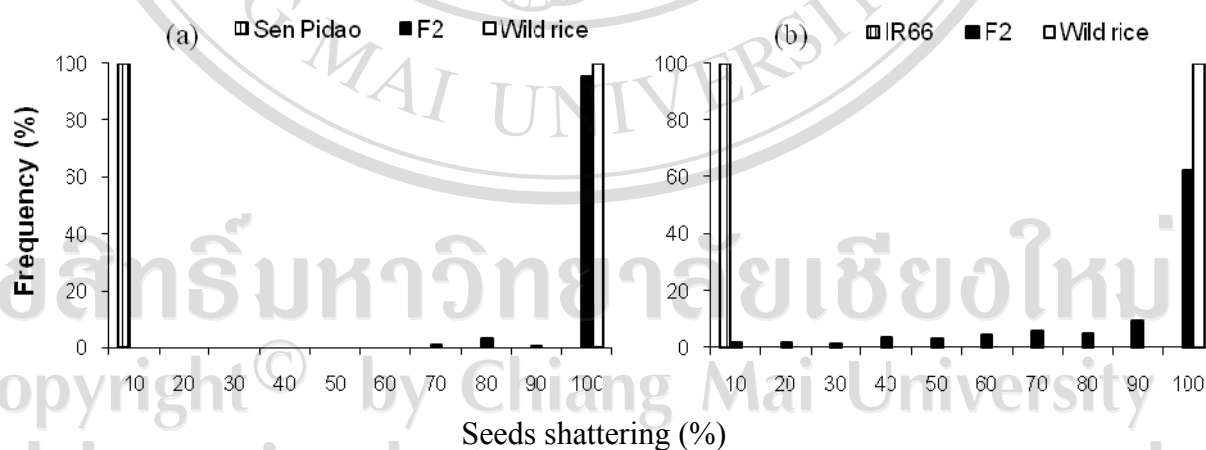


Figure 4.12 Distribution of numbers of seeds shattering (%) of F₂ populations between Sen pidao (SPD) x wild rice from Takeo province (TKWR) and IR66 x wild rice from Kampong Thom province (KTWR).

(a) SPD x TKWR; mean and SD for SPD, TKWR and F₂s were 1%±1, 99%±6, and 100% respectively.

(b) IR66 x KTWR; mean and SD for IR66, KTWR and F₂s were 0%±1, 83%±25, and 100% respectively.

Seed width (mm)

For the parents, seed width of cultivated rice SPD and IR66 parents ranged from 2.01-2.91mm. Those of wild rice (TKWR) and (KTWR) were ranged from 1.80-2.80mm. Transgressive segregations were observed in F₂ from cross between IR66 x KTWR, while crossing between SPD x TKWR segregated within the range of parent (Table 4.35).

Seed length (mm)

For the parents, seed length of cultivated rice SPD and IR66 parents ranged from 7.72-11.23mm. Those of wild rice (TKWR) and (KTWR) were ranged from 5.60-9.00mm. For F₂ populations, the F₂ plants segregated within the range of both parents (Table 4.36).

Seed shape

Based on (Oka, 1988) was classification of grain shape into three types: round, slender and large grain type. In present study, both cultivated rice SPD and IR66 parents had 100 % slender grain type, while wild rice parents Takeo (TKWR) and Kompong Thom (KTWR) was found about 92 -93% slender and about 7-8 % round grain types. For both F₂ segregation populations produced only slender seed type (Figure 4.13 and 4.14).

Table 4.35 Range, mean and standard deviation (Sd) of seed width (mm) of parents of F₂ populations from crosses between cultivated rice (IR66) x wild rice from Kampong Thom province (KTWR), and Sen pidao (SPD) x wild rice from Takeo province (TKWR).

Crosses	Seed width (mm)			
	N	range	mean	sd
Sen Pidao x Takeo wild rice				
- Sen pidao (SPD)	100	2.06-2.91	2.32	0.13
- Takeo (TKWR)	100	1.80-2.40	2.08	0.15
- F ₂	196	1.94-2.90	2.38	0.16
IR66 x Kompong Thom wild rice				
- IR66	100	2.01-2.63	2.32	0.12
- Kampong Thom province (KTWR)	100	1.90-2.80	2.36	0.17
- F ₂	189	2.06-2.98	2.45	0.18

Table 4.36 Range, mean and standard deviation (Sd) of seed length (mm) of parents of F₂ populations from crosses between cultivated rice (IR66) x wild rice from Kampong Thom province, and Sen pidao (SPD) x wild rice from Takeo province.

Crosses	Seed length (mm)			
	N	range	mean	sd
Sen Pidao x Takeo wild rice				
- Sen pidao (SPD)	100	8.27-11.23	9.86	0.52
- Takeo (TKWR)	100	5.60-9.00	7.13	0.65
- F ₂	189	6.94-11.06	8.60	0.71
IR66 x Kompong Thom wild rice				
- IR66	100	7.72-9.66	8.75	0.49
- Kampong Thom province (KTWR)	100	6.69-8.80	7.68	0.41
- F ₂	189	7.18-10.00	8.31	0.54

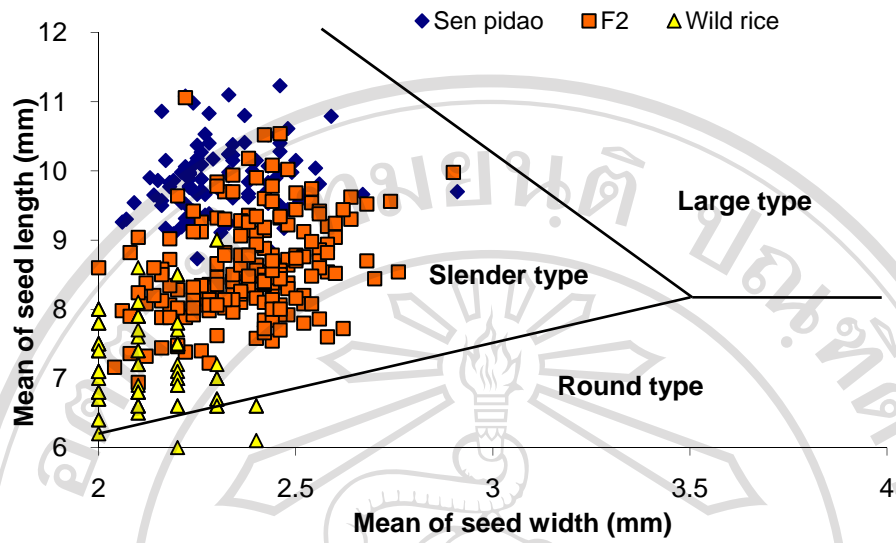


Figure 4.13 Distribution of seed shape of F₂ populations between cultivated rice (Sen pidao) x wild rice (Takeo) compared with their parents.

Source: (Oka, 1988)

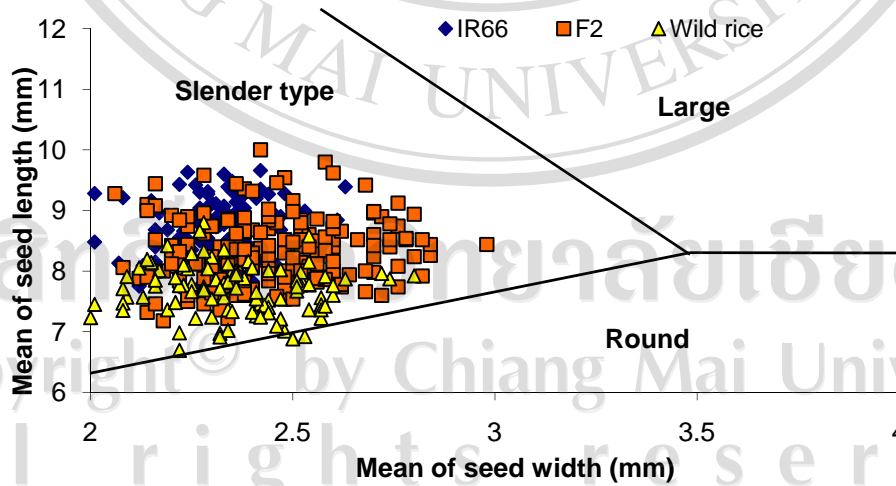


Figure 4.14 Distribution of seed shape of F₂ populations between cultivated rice (IR66) x wild rice (Kompong Thom) compared with their parents.

Source: (Oka, 1988)