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Crossability between cultivated rice (*Oryza sativa*) and common wild rice (*O. rufipogon*) and characterization of F_1 and F_2 populations

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ABSTRACT: Gene flow between cultivated and wild rice is considered to be the origin of weedy rice, a threat to rice production in Thailand since 2001. The present study determined the degree of cross compatibility between four cultivated rice (*Oryza sativa*) varieties, namely, two high yielding varieties, CNT1 and SPR1 and two pure lined traditional varieties, KDML105 and RD6, and two common wild rice biotypes (*O. rufipogon*) from Kanchanaburi (KC) and Nakorn Nayok (NY). The hybrid progeny in the F_1 and F_2 generations were characterized for selected traits. The cultivated and wild rice cross fertilized with different degrees of compatibility between different parents, with higher seed set in crosses involving the high yield varieties than with the traditional varieties. The F_1 hybrids were mostly fertile, exhibiting wild traits of spikelet awning, seed shattering, and red pericarp with hybrid vigour in panicle size from crosses between cultivated and NY wild rice, followed by transgressive segregation in the same characteristics in the F_2's. Genotypic effects of the cultivated and wild rice parents were shown in segregation of flowering time, culm length, and seed shattering of the F_2 plants. Segregation of seed shattering pattern in the F_2 differed between the wild rice parents; offspring of NY shattered their seed completely, while some of those of KC did not all shatter their seed. Genotypic effects of the wild and cultivated rice parents, especially in those traits important to survival and dispersal, suggest a range of possible recombinations that may need to be considered in effective control of the weedy rice and for the conservation of wild rice in situ.

KEYWORDS: weedy rice

INTRODUCTION

Weedy rice has become a serious invasive weed in rice growing areas in Thailand since 2002, causing rice yield losses ranging from 10–100% depending on the level of weedy rice infestation[1]. Hybridization between cultivated and wild relatives is one hypothesis for the origin of the weedy form. Natural hybridization has often been observed in crop/wild ancestor complex in 22 crop species, including rice[2]. Asian cultivated rice (*Oryza sativa* L.) is a predominantly self-pollinated crop with 0–1% outcrossing rate[3]. A higher cross-pollination rate has been reported in its progenitor, the common wild rice (*O. rufipogon* Griff.), with 7 to 55% outcrossing[4]. In Thailand, evidence of natural gene flow has been observed since 1961, when the waxy gene was found in the generally non-waxy common wild rice populations that were growing close to glutinous rice fields[5]. It has been suggested that in areas where cultivated and common wild rice are found sympatrically, the weedy rice originated from gene flow between them[6].

Gene flow between cultivated and wild rice has been reported in the range of 1.21–2.19%[7], while natural hybridization between cultivated and weedy rice has been reported to lie between 1–52%[8]. The rate of gene flow would be expected to be dependent on the genotypes and their flowering time. In Thailand, farmers choose to grow a particular variety in their field depending on market demand, farmers' own taste preference, and suitability of the variety to limitations of each field. The native common wild rice, which is still commonly found in rice growing areas throughout the country, also showed differentiation of populations by geographical distance and life history[4]. To assess the potential of gene flow between local wild rice and cultivated rice, the first step is to study whether rice varieties can indeed hybridize with common wild rice collected from main rice growing areas, and to determine if cross compatibility varies with the crop rice varieties and wild rice parents. If they can hybridize, the next step is to evaluate whether the hybrids can survive and reproduce. Segregation patterns will inform on survival and adaptation of the offspring from different cross-combinations. Understanding the extent and consequence of gene flow would contribute towards control and management of weedy rice and help in efforts to preserve genetic diversity of the common wild rice.

In this study, we collected common wild rice from areas where the first invasive weedy rice was reported[1]. We crossed these two wild rice biotypes with popular cultivated rice varieties and evaluated seed set, survival, and reproduction of the offspring and examined phenotypic variation between parents, and the F_1 and F_2 populations.

MATERIALS AND METHODS

Crossability between cultivated rice and wild rice

Four cultivated rice varieties, two high yielding varieties (HYVs), Suphanburi 1 (SPR1) and Chainat 1 (CNT 1), and two pure lined traditional varieties, Khao Dawk Mali 105 (KDML105) and RD6, were used as female parents. Common wild rice (*O. rufipogon*) collected from two different locations in the Central Plain of Thailand, Kanchanaburi (KC) in the west and Nakhon Nayok (NY) in the east were used as the male parents. Crosses were made between all varieties of cultivated rice and wild rice, resulting in 8 hybrid combinations. For all of the parents, seeds were pre-germinated in petri dishes for 5 days and then seedlings were transferred to undrained pots (30 cm diameter, 30 cm deep) containing a light soil of the San Sai series. When the rice seedlings were about 10 cm tall, the pots were kept flooded with about 5 cm of water above the soil surface until maturity. Fertilizers and pesticides were applied uniformly to avoid nutrient deficiency and insect infestation.

Twenty plants of each of the cultivated rice varieties were sown in pots, 5 plants per pot on 4 planting dates. Common wild rice was propagated vegetatively from stems with rooted nodes collected from the natural habitat. Artificial hybridization between the cultivated and wild rice were made following the method described by Ref. 9 in the rainy season of 2002. Cultivated rice varieties were used as female parents. Ten to 15 panicles of each variety were emasculated (10 to 20 spikelets per panicle). Pollination was made at the ratio of 3 female spikelets to 1 anther from the wild parent. At maturity, the pollinated panicles were harvested and percentage seed set (the ratio of the number of seeds set to the number of spikelets fertilized) were determined. Seeds from each cross were kept at 4 °C and used in the next experiment.

Evaluation of F_1 and F_2 hybrids of cultivated and wild rice

In the rainy season 2003, twenty plants of each F_1 hybrids and their parents from all combinations of crosses were grown to maturity in four pots as described above. The pots were arranged in a completely randomized design with four replicates. Seed germination was recorded, followed by number of normal seedlings at four weeks after sowing. F_1s, and parent plants were characterized individually for morphological and physiological characters using the method given in Ref. 10. At flowering, plants were recorded for the presence of awn on spikelets and days to flowering. At maturity, the culm length of each plant was measured. Culm length was measured from the soil surface to the collar of the tallest panicle. Each plant was harvested separately. Two panicles from each plant were randomly collected and measured for seed fertility, seed shattering (by tapping each panicle lightly and counting the number of seeds shed), and scored for hull and pericarp colour. Seeds of each F_1 hybrid and their parents were kept separately at 4 °C and sown in the wet season of 2004. A total of 120–170 of the F_2 plants and 20 plants of each parent were grown in pots, 10 plants per pot. Plants in the F_2 generation were also evaluated for morphological and physiological characters.

Data analysis

Means of each physiological character of the F_1s hybrids and their parents were separated by using Duncan's Multiple Range Test at $P < 0.05$. F_2 segregation data for morphological characters were tested for goodness-of-fit to 1-, 2- and 3-gene models by chi-squared analyses and the frequency distribution was applied for all physiological characters.

RESULTS

Crossability between cultivated and wild rice

All of the cultivated rice varieties crossed successfully with both of the wild rice varieties. However, the percentage of seed set was significantly different among cultivated rice × wild rice combinations (Table 1). For a given cultivated rice parent, the percentage of seed set was dependent on the wild rice parent, and vice versa for a given cultivated rice parent. For the crosses with KC wild rice, the highest percentage of seed set was found with the HYV's, CNT1 (35%), and SPR1 (36%). For the crosses with NY wild rice, the highest percentage of seed set was again found in SPR1 (62%), and the lowest with CNT1 (10%).

Table 1 Seed set of crosses between four cultivated rice (as female) and two common wild rice, KC and NY, (as male) parents, seed germination and seedling survival of F_1 hybrids.

Cultivated rice	Wild rice male parent					
female parent	KC	NY	KC	NY	KC	NY
	Seed set (%)		Seed germination (%)		Seedling survival (%)	
CNT1	35	10	25	60	86	100
SPR1	36	62	70	85	86	82
KDML105	11	43	75	70	100	86
RD6	6	26	55	80	90	83
SE	8	11	11	5	3	4

SE is the pooled standard error

Seed germination and seedling survival

There was a large variation of seed germination of the F_1 hybrids from both wild and cultivated rice parents (Table 1). Germination ranged from 25 to 75% in the hybrids of KC wild rice whereas 60 to 85% were in those from NY wild rice. Among the different cultivated rice varieties, the lowest germination was observed in the F_1 seeds which were from the cross of CNT1 with both KC (25%) and NY (60%). Following germination, survival to seed set and maturity in the F_1 hybrids ranged from 82% to 100%.

Morphological and physiological traits

All four cultivated rice varieties had erect plant type, awnless spikelets, seed that shattered very little at maturity, and endosperm with white pericarp. The wild rice (KC and NY) had spreading plant type, awned spikelet, seed that shattered almost completely to completely at maturity, and endosperm with red pericarp. The F_1 hybrids from all of the crosses exhibited spikelet awning, seed shattering at maturity and red pericarp, resembling the wild parent, but plant type was intermediate between the parents (Table 2). For the F_2 generation, the wild traits were dominant over cultivated traits and appeared to be controlled by 1–3 genes. The number of putative genes controlling plant type and spikelet awning were different among the different crosses.

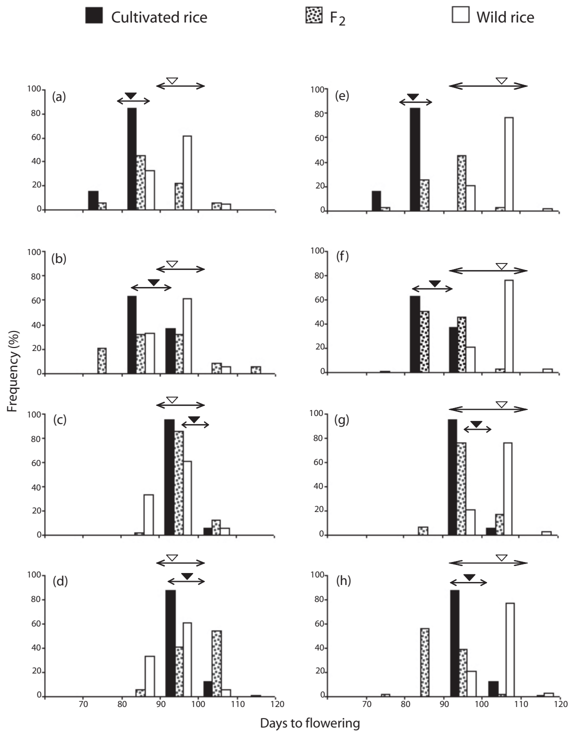

Fig. 1 Distribution of days to flowering of F_2 populations. In this and subsequent figures: cultivated rice × KC wild rice (*left*) and cultivated rice × NY wild rice (*right*). Inverted triangles indicate the mean for parents (filled symbols: cultivated rice; hollow symbols: wild rice) with range in associated horizontal bars. (a) CNT1 × KC (b) SPR1 × KC (c) KDML105 × KC (d) RD6 × KC (e) CNT1 × NY (f) SPR1 × NY (g) KDML105 × NY (h) RD6 × NY

Days to flowering

With the same planting date of 28th July 2003, there was a significant spread in days to flowering of 84 to 98 days among the cultivated rice parents and 99 to 105 days for the wild rice parents. Days to flowering in the F_1 hybrids were either similar to one parent or falling between the parents, depending on parental combinations (Table 3). With KC as the wild parent, the F_1s from CNT1 and SPR1 were closer to the wild parent in flowering time. The flowering dates of F_1 hybrids between cultivated rice with NY wild rice were closer to cultivated rice for all crosses. Normal, continuous segregation of days to flowering of the F_2's was found to be within the range of that of the parents for all crosses. The spread of days to flowering of the F_2's derived from the photoperiod insensitive SPR1 and CNT1 cultivated rice parents covered a much larger range than the other crosses (Fig. 1).

Culm length

Culm length of the parents was shortest in the semi-dwarf SPR1 and CNT1, and longest in the wild parents (Table 3). F_1 hybrids were taller than the cultivated rice parents. Mean of culm length of F_1 hybrids ranged from 123 to 157 cm (Table 3). In the F_2

Table 2 Morphological characteristics of F_1 hybrids and segregation of F_2 populations between cultivated rice and wild rice compared with their parents.

				F_2 segregation				
Character	Cultivated rice	Wild rice	F_1	Ratio	No. of gene	Cross		P
						KC	NY	
Plant type	erect	spreading	intermediate	3:1	1	-	CNT1, SPR1	0.22–0.69
				15:1	2	all	KDML105, RD6	0.08–0.27
Spikelet awning	awnless	awned	awned	3:1	1	CNT1, SPR1	all	0.07–0.48
				15:1	2	KDML105, RD6	-	0.64–0.81
Seed shattering	non-shattered	shattered	shattered	63:1	3	all	all	0.23–0.89
Pericarp colour	white	red	red	3:1	1	all	all	0.09–0.64

Table 3 Mean values for days to flowering, culm length, panicle length, number of primary branches, spikelets and seeds per panicle, filled seed and seed shattering of 8 F_1 hybrids between cultivated rice and common wild rice and their parents.

Genotype	Days to flowering	Culm length (cm)	Panicle length (cm)	No. of spikelets per panicle	No. of seeds per panicle	% filled seed	% shattering
Parent cultivated rice							
CNT 1	83.5 ^{e†}	70.5 ^{i}	25.0 ^{d}	143.5 ^{cd}	131.2 ^{b}	96.0 ^{a}	1.4 ^{g}
SPR 1	87.7 ^{d}	81.0 ^{h}	24.2 ^{d}	142.2 ^{cde}	129.5 ^{b}	94.4 ^{a}	1.3 ^{g}
KDML 105	97.6 ^{b}	110.9 ^{g}	22.7 ^{e}	130.9 ^{def}	114.2 ^{bcde}	88.2 ^{b}	3.2 ^{g}
RD 6	97.0 ^{bc}	123.0 ^{f}	24.0 ^{de}	131.5 ^{cdef}	120.7 ^{bcd}	87.7 ^{b}	2.8 ^{g}
Common wild rice							
KC wild rice	99.4 ^{b}	136.6 ^{cd}	26.7 ^{c}	125.1 ^{ef}	106.9 ^{bcde}	73.0 ^{e}	100.0 ^{a}
NY wild rice	105.2 ^{a}	139.5 ^{bcd}	26.9 ^{c}	130.6 ^{def}	100.3 ^{de}	76.7 ^{de}	100.0 ^{a}
F_1							
CNT1 × KC	98.9 ^{b}	128.4 ^{ef}	22.7 ^{e}	141.6 ^{cde}	120.1 ^{bcd}	84.8 ^{bc}	90.5 ^{e}
SPR1 × KC	97.3 ^{bc}	128.2 ^{ef}	24.7 ^{d}	117.2 ^{f}	94.7 ^{e}	80.9 ^{cd}	93.0 ^{de}
KDML105 × KC	99.0 ^{b}	135.9 ^{cd}	24.0 ^{de}	120.2 ^{f}	103.3 ^{cde}	85.9 ^{bc}	99.0 ^{ab}
RD6 × KC	97.1 ^{bc}	142.9 ^{bc}	24.7 ^{d}	149.5 ^{bc}	111.4 ^{bcde}	74.7 ^{e}	86.0 ^{f}
CNT1 × NY	87.6 ^{d}	132.3 ^{de}	29.5 ^{a}	174.2 ^{ab}	127.7 ^{bc}	87.6 ^{b}	96.7 ^{bc}
SPR1 × NY	89.1 ^{d}	122.5 ^{f}	27.5 ^{bc}	165.7 ^{ab}	116.7 ^{bcde}	76.4 ^{de}	86.7 ^{f}
KDML105 × NY	97.1 ^{bc}	144.3 ^{b}	28.5 ^{ab}	177.6 ^{a}	129.6 ^{b}	63.5 ^{f}	97.5 ^{abc}
RD6 × NY	94.6 ^{c}	157.0 ^{a}	27.7 ^{bc}	177.6 ^{a}	160.5 ^{a}	76.4 ^{de}	95.6 ^{cd}

† Means within a column with the same letter do not differ significantly ($P < 0.05$) with Duncan's Multiple Range Test.

generation, normal, continuous segregation was found for all crosses. F_2 plants were segregated within the range of the parents. Segregation of culm length of the F_2's derived from SPR1 and CNT1 cultivated rice varieties showed much wider spread than the other crosses (Fig. 2).

Panicle length

Panicle length of cultivated parents was between 22 and 25 cm. Those of KC and NY wild rice were longer, with a mean of 26 cm. Mean panicle length of the F_1 hybrids between cultivated × KC wild rice were also between 22 and 25 cm. Heterosis of F_1 hybrids was observed in CNT1 and KDML105 × NY wild rice crosses (Table 3). Normal distribution was found in all F_2 populations for this character. For F_2 populations derived from cultivated rice × NY, transgressive segregation in panicle length was found for all crosses (Fig. 3).

Number of spikelets per panicle

The number of spikelets per panicle of cultivated rice ranged from 130 to 143 (Table 3). For cultivated rice × KC wild rice crosses, spikelets per panicle of F_1 derived from CNT1 and RD6 were the same as cultivated parents. The F_1 from SPR1 × KC had fewer spikelets per panicle than either parent. For cultivated rice × NY crosses, most F_1 had more spikelets per panicle than both parents. Transgressive segregation was observed in the F_2 populations, especially those deriving from NY crosses (Fig. 4).

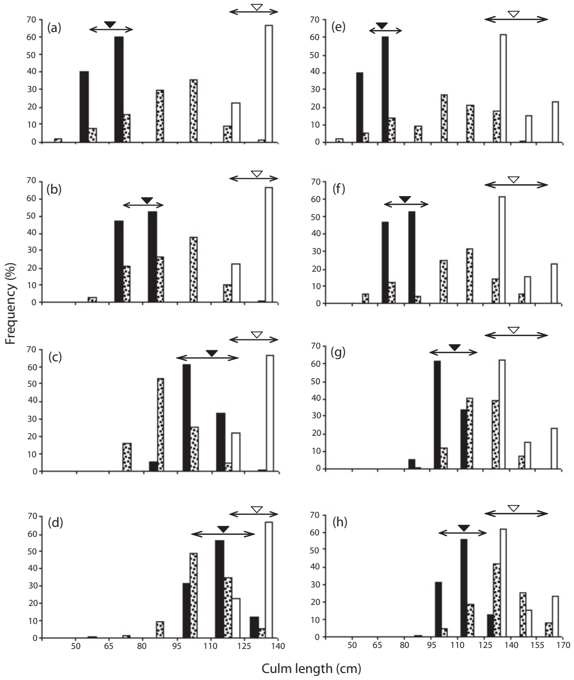

Fig. 2 Distribution of culm length (cm) of F_2 populations.

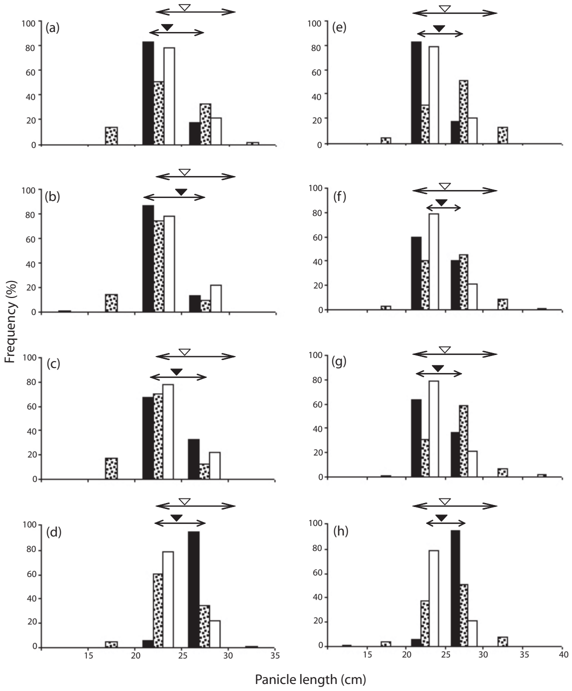

Fig. 3 Distribution of panicle length (cm) of F_2 populations.

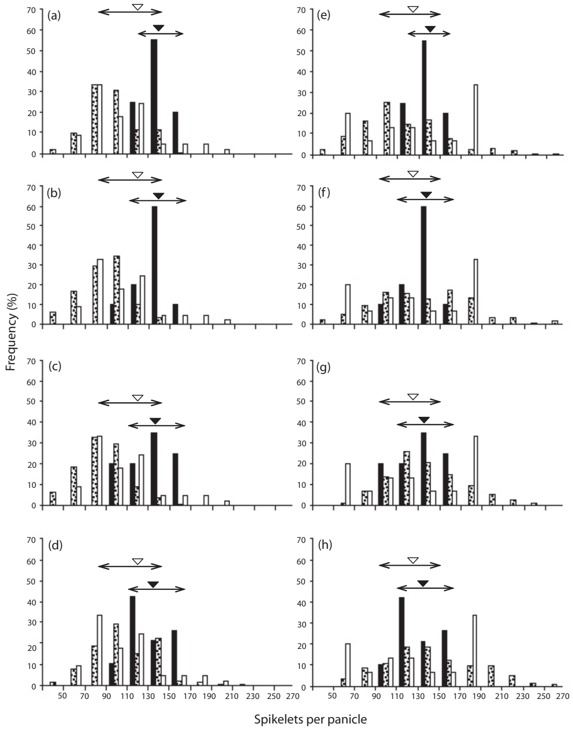

Fig. 4 Distribution of spikelets per panicle of F_2 populations.

Number of seeds per panicle

In cultivated rice, the number of seeds per panicle ranged between 114–131, while in the wild rice it ranged from 100 to 107 (Table 3). Seeds per panicle of the F_1's from all crosses, except RD6 × NY, were similar to one or intermediate between the two parents. The average number of seed per panicle of the F_1 hybrids between RD6 × NY was higher than both parents. For F_2 populations, transgressive segregation was observed, but in different directions with different wild rice parents. The F_2 populations derived from cultivated rice × NY crosses had more seeds per panicle than both parents, while those F_2 populations with KC as the wild parent had fewer seeds per panicle than either of their parents (Fig. 5).

Filled seed

Percentage of filled seed of cultivated rice varied from 87–96% and somewhat lower in the wild rice, at 73% for KC, and 77% in NY wild rice (Table 3). For the F_1 hybrids between cultivated × KC wild rice, the percentage filled seed in the F_1 from KDML105 was the same as in cultivated rice, while the rest were intermediate between parents. For cultivated rice × NY combinations, filled seed of the F_1 hybrids derived from CNT1, SPR1, and RD6 were intermediate between parents, except KDML105 × NY had a lower percentage of filled seed than both parents. Transgressive segregation was observed in the F_2 generation,

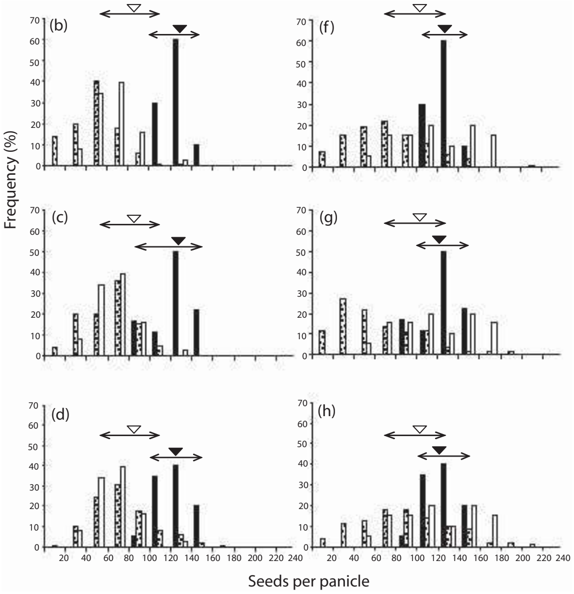

Fig. 5 Distribution of seeds per panicle of F_2 populations.

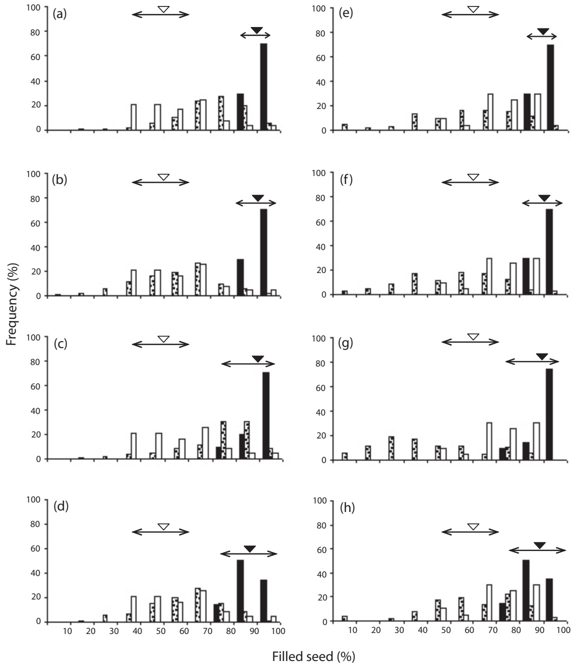

Fig. 6 Distribution of filled seed (%) of F_2 populations.

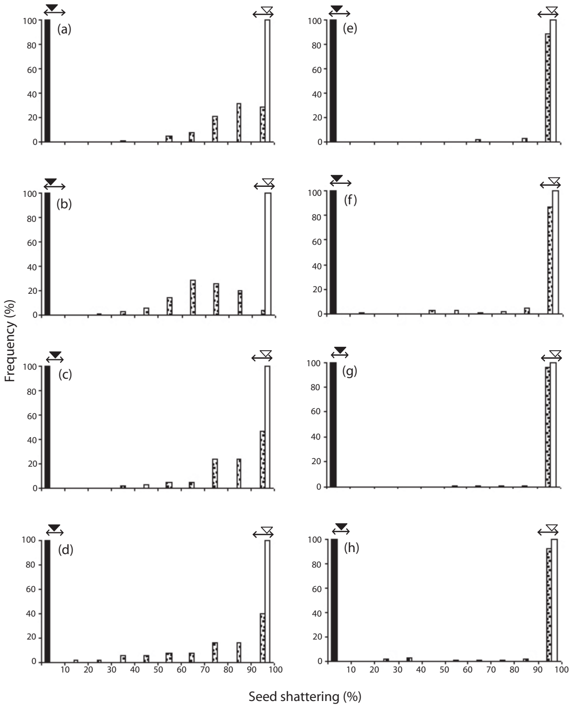

Fig. 7 Distribution of seed shattering (%) of F_2 populations.

with a percentage of filled seed that ranged from 0 to 100% (Fig. 6).

Seed shattering

Panicles of KC and NY wild rice shattered their seed completely. Percentage seed shattering of cultivated rice varieties were between 1.4–4.6% (Table 3). Seeds of the F_1 hybrids between cultivated and wild rice shattered with the same rate as or close to their wild rice parents. However, the segregation pattern of seed shattering was different between crosses, with a distinctive pattern for each of the wild parents; 85–97% of F_2 plants with NY as the wild parent had seed shattering in the range of 91–100%. In contrast, only 3–47% of the F_2 plants with KC as the wild parent had seed shattering in the 91–100% range (Fig. 7).

DISCUSSION

This study has confirmed previously reported results[11,12] that wild and cultivated rice can readily hybridize. In this study, we have found variation due to both wild and cultivated parents in the hybridization success, germination, and phenotype of the offspring and their segregation in the F_2 generation. Differences were found in cross compatibility between parents (% seed set), phenology, culm length, and seed production of F_1 hybrids. In F_2 populations, different patterns of segregation, flowering date, and culm length were associated with different cultivated rice parents, whereas differences in seed shattering were associated with wild rice parents.

For the cross-compatibility study, we found that all cultivated rice and common wild rice genotypes were interfertile and produced normal F_1 seeds but with different rates of seed set. The highest seed set was found with the HYV, SPR1, crossed with both KC (36%) and NY (62%) wild rice. Spontaneous hybridization or gene flow between cultivated and common wild rice was shown to vary from 1.21% to 2.19% under field experiments[7] or even as high as 52% between cultivated rice and weedy rice[8]. From this study, we do not intend to imply that the rate of seed set by hand pollination between cultivated rice and common wild will be the same under natural conditions. Rather, the results indicate that there was a lower genetic barrier between cultivated rice and common wild rice in Thailand than has been shown between *indica* and *japonica* rice[6]. When crossed with wild rice, the higher percentage seed set with HYVs compared to traditional varieties found in the present study could suggest a high potential for natural gene flow between the HYVs and wild rice. The HYVs are insensitive to the 11–13 hour days in Thailand's rice growing region, and are normally grown in a continuous production system with 2–3 crops per year on the same land. Thus, they will have a better chance of flowering in synchrony and outcrossing with the sympatric wild rice than traditional varieties which are grown and flower at specific dates only once a year. This interpretation would need to be confirmed with crosses involving a wider range of genotypes.

In the F_1 generation, all of the interspecific hybrids exhibited intermediate plant type between parents, but having phenotype of the wild parent in spikelet awning, red pericarp, and seed shattering habit. Segregation of the phenotypes in the F_2 indicated that the wild characters in this study were controlled by few major dominant genes (1–3 genes) as reported in Refs. 13, 14. Compared with the cultivated rice parents, the F_1 hybrids were taller, but for the other characters the hybrids varied depending on the cross-combinations. Heterosis for panicle length and spikelets per panicle was found in F_1 hybrids derived from cultivated rice × NY wild rice. Moreover, transgressive segregation of F_2 plants were found in panicle length, spikelets, and seeds per panicle. This confirmed that the interspecific hybridization produced a large source of genetic variation and adaptation via transgressive segregation. This information may be useful in plant breeding. However, interspecific hybridization will also enhance weediness in invasive weedy rice in certain circumstances. For example, McCouch et al[15] found transgressive variation for yield and yield components in BC_2F_2 populations derived from *O. sativa*, *indica*, and *japonica* ssp. with common wild rice (*O. rufipogon*). In many traits, the source of trait-enhancing alleles were found in *O. rufipogon*. Zhang et al[16] also found that the segregating population derived from cultivated rice and their wild relatives demonstrated a high level of rapid adaptability for changing environments. On the other hand, gene flow between cultivated and wild relatives will create more aggressive weeds[2]. Weedy rice populations emerging in Thailand have been found to contain a large amount of genetic variability[1]. Risk of introgression of new traits into weedy rice in the area by gene flow from cultivated rice should be monitored before the introduction of new varieties, including transgenic ones.

A greater range of segregation of F_2 plants in flowering and culm length were found from populations derived from HYVs × wild rice genotypes than those derived from the traditional varieties. Therefore, hybrids derived from HYVs will have some advantage such as longer duration of flowering, which will increase the chance for further gene flow with new introduced varieties. Height advantage will help to promote competition of weedy rice in the field. From this study, it could be predicted that weedy rice originating from HYVs × wild rice hybrids might be more invasive than from traditional varieties × wild hybrids. However, further studies are needed to examine crosses from a wider range of cultivated and wild rice genotypes, and explore the effects of new introduced traits.

Differential segregating patterns between different crosses will have implications for the control of invasive weedy rice and the conservation of the common wild rice in situ. At least three types of weedy rice have been recognized by farmers[1]. *Khao Hang* is awned, taller than crop rice and shatters seed; *Khao Deed* is awnless, shorter than crop rice and shatters seed; *Khao Daeng* or *Khao Lai* has no awn, looks like crop rice in the husk, but a lot of the grains have red pericarp. The emergence of these different kinds of invasive weedy rice is in agreement with different patterns of segregation associated with different genotypes of cultivated and wild rice parents found in this study. For example, seed shattering in the F_2 is segregated differently with different parents. Almost all of the F_2 plants derived from NY wild rice shattered their seed almost completely, while more than half of those derived from KC wild rice did not shed some of their seeds. This suggests different gene actions between the wild rice parents; it appears that there is complete dominance for crosses derived from NY wild rice and complementary gene action for crosses derived from KC wild rice. These results further imply that the different populations of weedy rice in Thailand originating from different wild rice parents will have different patterns of seed dispersion. For example, most of the weedy rice containing shattering genes from NY type wild rice will be of the high shattering type. They will shatter most seed into the soil and rapidly build up the seed bank. On the other hand, weedy rice containing shattering genes from KC type wild rice should have both intermediate and high shattering types in the population. Therefore, some of the seeds will contribute to the seed bank in the soil and those remaining on the panicles will be harvested with the crop. And as the harvested rice crop is commonly used also as seed, this type of weedy rice will spread to other areas in the contaminated seeds more readily than the type with completely shattered seed.

Previous studies have shown that gene flow between cultivated and wild rice is likely to result in the introduction of alien genes into wild rice populations. Brown plant hopper resistance was found in wild rice in the central plain of Thailand where modern varieties with this resistance are grown all year round[17]. In a field experiment a herbicide resistance allele from a herbicide-resistant cultivated rice variety has been traced to wild rice populations[18]. Microsatellite markers for KDML105, Thailand premier jasmine variety released in 1959, has been detected in wild rice in Tung Kula Ronghai, the country's main jasmine rice area[19], where the variety has been grown extensively for only about 30 years. It has been suggested that gene flow could lead to loss of genetic diversity and extinction of wild rice populations[2,20]. In this study we have shown for the first time that the impact of gene flow on the wild rice will depend on the segregation pattern of the progeny, which is determined by genotypes of both wild and domesticated parents.

This study has demonstrated significant variation in hybridization due to parental combinations between wild and cultivated rice and its consequences. We have shown how genotypes of the wild and cultivated rice parents can influence segregating patterns in adaptation traits of the offspring. Further evidence has been provided in support of the hypothesis that the emergence of invasive weedy rice in Thailand's rice growing areas has originated from hybridization between cultivated and native wild rice. Understanding how variation in the genotypes of wild and cultivated rice parents can affect segregating patterns in adaptation traits of the hybrid progeny, including seed dispersion and survival, will assist in integrated weed management in different rice growing regions where common wild rice is prevalent, and also assist in conservation of the wild rice in situ.

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