

Evaluation of the agronomic and genotypic diversity of Thailand local rice (*Oryza sativa* L.) varieties under lowland conditions

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ABSTRACT: Local Thai varieties of rice contain high levels of genetic diversity. Thus, understanding the genetic structure and relationships among local varieties will be useful for parent selection in rice breeding programs. This study aimed to evaluate the agronomic and genetic variation in a collection of 82 local Thai germplasms from 4 regions of Thailand. The agronomic traits and the Shannon-Weaver index (H') were used to determine phenotypic diversity. In addition, a set of 82 diverse local varieties were genotyped using 75 SNP markers to assess the structural analysis and phylogenetic tree. The results showed that phenotypic variation among 82 varieties was found in all traits. Most local Thai varieties were photosensitive varieties, the plant height was tall to very tall (> 140 cm), the panicle number was low (10–20 panicles), the panicle length was long (> 25 cm), and the grain shape was slender. A moderate H' index was found for panicle number, panicle length, and grain weight. The structural analysis was classified into 5 subpopulations. It was clear to separate glutinous rice (group II) and non-glutinous rice (group I, III, IV, and V). In addition, it is sufficient to be able to differentiate by region in some groups, but it cannot be classified according to the ecology (upland and lowland) and grain shape. Moreover, the results of the phylogenetic tree were associated with the analysis of the structure. Therefore, local Thai rice varieties may be beneficial in terms of rice germplasm that can be used in breeding programs.

KEYWORDS: SNP markers, genetic diversity, phenotypic diversity, rice (*Oryza sativa* L.)

INTRODUCTION

Rice (*Oryza sativa* L.) is a key food crop in Thailand and Asia; it involves 3.55 million households of rice farmers in Thailand [1]. In addition, Thailand is consistently ranked among the top 3 rice exporting countries in the world and has a market share of approximately 24 percent of world rice exports [2]. Although Thailand is one of the world's leading rice exporters, Thailand is losing its competitiveness, especially for white rice exports, because yield is decreased and affected by often erratic weather conditions [2]. Therefore, local varieties that contain high levels of genetic diversity can provide an opportunity for plant breeders to select and improve new cultivars [3], which include established grain yield under inappropriate environmental conditions. However, Southeast Asia, including Thailand, has experienced a significant loss in rice diversity due to economic and political globalization, the adoption of high-quality, high-yield rice varieties from modern agriculture, and changes in traditional farming systems and ethnic cultures [4].

To succeed in a rice breeding program as well as prepare for unforeseen breeding challenges in the changing environment, a wider genetic base of

germplasm is needed [5]. This vast wealth of rice germplasm, including local and traditional varieties, is a good source of important alleles to develop new rice varieties [6]. Locals are local and often ancient varieties of a crop that are grown by traditional farmers [3]. Locals have been found to be genetically dynamic and display equilibrium with both the environment and pathogens; thus, they could provide valuable and useful genetic resources for crop improvement [7]. Thailand is one of the most significant and unique countries for plant genetic resources and crop diversity, especially for rice [8]. Thailand lies partly in the center of rice diversity and in the region where rice was originally domesticated [9], which has a large collection of diverse rice germplasms [10]. The Department of Rice in Thailand reported that approximately 24,000 rice accessions are found in Thailand. They are collected and have been preserved in several National Rice Gene Bank collections for decades. There are approximately 17,000 rice accessions reported as native Thai rice. However, evaluations of genetic diversity and relationships among Thai rice germplasm collections have been limited [11].

Therefore, estimates of genetic diversity and the relationships among varieties are very useful for fa-

cilitating efficient germplasm collection and management [5]. Phenotyping is an important activity to evaluate the first-hand information on the utilization of germplasm fundamental to provide necessary information for plant breeding programs [12, 13]. In conventional plant breeding, genetic diversity is based on morphological variation in quantitative traits, which is easy to study and cost-effective [14]. Morphological characterization is the first step in the classification and evaluation of the germplasm [15, 16]. Several morphological characteristics are the major determining factors of rice grain yield such as number of spikelets per panicle which is one of the important traits to increase yield potential [17]. The recognition of genetic variability in any character involved during yield synthesis provides a scope for the possibility of rice breeding programs [5].

Thailand can be divided into 4 regions: the mountains and forests of the North; the vast rice fields of the Central Plains; the semiarid farmlands of the Northeast Plateau; and the tropical islands and long coastline of the South Peninsula. Each region has different rice-growing environments [10]. Therefore, in this study, the diversity of 82 local rice germplasms collected from the central, northern, northeastern, and southern regions of Thailand by the National Rice Gene Bank collection was used to investigate the agronomic and genotypic variation for 2 seasons under lowland conditions (flooding system). Information generated from phenotyping and genotyping of these germplasms can be used as a basis for future collection trips to augment diversity in gene bank collections as well as baseline information for utilization in rice breeding programs.

MATERIALS AND METHODS

Local Thai varieties

During the pre-experiment, 62 upland rice varieties were grown and evaluated in flooded conditions; this experiment found that 40 varieties were able to grow in flooded conditions such as lowland rice (data not shown). Therefore, 40 upland rice varieties together with 42 lowland rice varieties were used to study genetic diversity. These varieties were received from the Thai National Rice Gene Bank, Department of Rice, Ministry of Agriculture and Cooperative, Thailand, and derived from the northern (22 varieties from 5 provinces), central (26 varieties from 14 provinces), northeast (16 varieties from 12 provinces), and southern (one variety from one province) regions of Thailand. However, some local varieties had unknown origins, including 8 varieties from the north, 10 varieties from the center, one variety from the northeast, and one variety from the south. In addition, 32 glutinous rice and 50 non-glutinous rice varieties were identified. All local varieties were categorized by genetic stock number (GS No.) (Table S1).

Experimental design and growth conditions

The experiment was conducted in the rainy season starting from 1 June–31 October 2018 and repeated in the mid-rainy season starting from 1 August–31 December 2018 at the Rice Research Station, Kasetsart University, Kamphaeng Saen, Nakhon Pathom Province, Thailand (14°01'N, 99°58'E, 10 m above sea level). The experimental plots of both seasons were laid out in accordance with a randomized complete block design with 3 replications. Each variety was planted in 2 rows (5 m/row) with a spacing of 25 × 25 cm, and the transplanting method under flooded conditions was applied. In addition, the experimental plots for 2 seasons were conducted in the same field at a 10 m distance, and a bund was constructed between the 2 plots.

The rice plants were seeded in a field nursery. After 15 d, each seedling plant was transplanted into the experimental plot. The soil fertility characteristics were determined by replicated analysis of 2 samples from each season from up to 40 cm in depth. The fertilizer was applied at 15 d after planting at a rate of 75 kg/ha of N, 37.5 kg/ha of P₂O₅, and 37.5 kg/ha of K₂O. The second split of fertilizer was applied at the booting stage (65 d after planting) at a rate of 37.5 kg/ha of N. The water management was conducted with flooded conditions by maintaining a water depth of 10 cm above the soil surface, and the water levels were not allowed to be more than 5 cm above the soil from 15 d after transplanting to 14 d before harvest. Other management practices were performed in accordance with conventional high-yield cultivation approaches [18]. The weather data, including air temperature, relative humidity, amount of rainfall, and day length, were measured every 3 h per d with a data logger (WatchDog 2000 Series Micro Stations, Spectrum Technologies, Inc., USA).

Agronomic trait collection

Agronomic data were collected over 2 seasons, including plant height (cm), days to flowering, culm number, panicle number, panicle length (cm), 100 grain weight (g), brown grain length and width (mm), brown grain length/width ratio, glume color, and pericarp color. Plant height, days to flowering, number of tillers per plant, and number of panicles per plant were measured at the end of the vegetative stage, while the other traits were measured at the maturity stage. The results were averaged from 10 randomly selected plants in each variety/replication. The classification of each agronomic trait was followed by descriptors for wild and cultivated rice (*Oryza* spp.) [19].

Phenotypic analysis

The Shannon-Weaver diversity index (H') was used to calculate the phenotypic diversity of the characterized local varieties following the protocol used by Sotto and

Rabara [20]. An arbitrary scale was adapted from Jamago and Cortes [21] to categorize the computed indices into maximum ($H' = 1.00$), high ($H' = 0.76-0.99$), moderate ($H' = 0.46-0.75$), and low diversity ($0.01-0.45$). The diversity indices of the collected germplasms were calculated based on phenotypic frequency using the standardized Shannon-Weaver diversity index formula:

$$H' = - \sum_{i=1}^S P_i \ln P_i,$$

where S is the number of phenotypic classes for a character and P_i is the relative frequency in the i -th class of the j -th trait. In addition, the classification of plant height, days of flowering, panicle length, brown grain length/width ratio, glume color, and pericarp color followed IRR1 [22].

Genotyping analysis

The pooled genomic DNA was extracted from 5 plants per variety using the DNeasy Plant Mini Kit (Qiagen) protocol. The DNA quantity was tested with a NanoDrop 8000, and the concentration exceeded 50 ng/ μ l. Genotyping was performed with 64 SNP markers using the KASP genotyping platform [23] and the SNpline genotyping system following standard KASP protocols [24]. The SNP marker set (64 markers) was received from the Rice Science Center, Kasetsart University, Thailand (Table S2).

The genotype data from polymorphic SNP markers of 82 local varieties were used to calculate the genetic distance using Nie's standard distance [25], and the phylogenetic tree was created using MEGA X based on the maximum-likelihood method. The STRUCTURE analysis was performed using a Bayesian model-based clustering algorithm implemented in STRUCTURE version 2.3.4 [26], where the admixture model with the correlated allele frequencies was used. A total of 3 independent replicates were run for each genetic cluster (K) value ($K = 1-8$) using a burn-in period of 100,000 and a run length of 100,000 iterations. $\ln P(D)$ values were derived for each K and plotted to find the plateau of ΔK [27]. The final population structure was calculated using the structure harvester [28].

Statistical analysis

All the data were analyzed using R program version 3.6.1 [29] to test the significance of the agronomic trait results. The means were separated using Duncan's test at alpha levels of 0.05. If there was a significant difference among the experiments for a given parameter, then the values from all of the experiments for that parameter were used to obtain the means and standard error. In addition, correlation analysis (r) was used to evaluate the agronomic traits.

RESULTS

Weather and soil properties

The weather data taken during the 7 months of the experiment from June–December 2018 are shown in Fig. 1. The mean daytime and nighttime temperatures for the 7 months were 29.5/23.4°C. However, the experiments of the 2 seasons had an overlapping period of 2 months. When considering the mean daytime and nighttime temperatures between the rainy season (Jun–Oct) and the mid-rainy season (Aug–Dec), it was found that the mean temperature during the rainy season (30.8/27.0°C) was higher than that in the mid-rainy season (29.5/25.5°C). In addition, the mean relative humidity during the day and nighttime over the 7 months was 85.1/68.1% RH. The total rainfall in the rainy season was 509.6 mm, while the total rainfall in the mid-rainy season was 307.4 mm. The length of the day with less than 12 h was on 29 September 2018.

The soil in the rainy season plot consisted of 1.56% organic matter, 0.07% total N, 26.70 mg/kg available P, 73.53 mg/kg exchangeable K, 629.0 mg/kg exchangeable Ca, and 76.50 mg/kg exchangeable Mg and had a pH of 5.40, while the soil in the mid-rainy season plot consisted of 3.82% organic matter, 0.10% total N, 29.40 mg/kg available P, 59.30 mg/kg exchangeable K, 1120.20 mg/kg exchangeable Ca, and 69.73 mg/kg exchangeable Mg and had a pH of 5.80.

Phenotypic of agronomic traits

Phenotypic variation among 82 varieties was found in all traits in both seasons. However, the replications in each season were not significant, and the percentage of coefficient of variation (% CV) in each trait was low. Therefore, the agronomic traits in each local rice variety used in the experiment in both seasons were uniformity (Table 1). When considering the interaction between genotype \times season, it was found that the days of flowering were significant, while the plant height, culm number, panicle number, and panicle length had no significant interaction. The days to flowering showed the most variation in the rainy season, ranging from 66–146 DAS. It was found that 24 varieties were identified as non-photosensitive varieties that exhibited flowering before day length of more than 12 h (29 September 2018). The Pah Leud Kwahy variety (66 DAS) had the shortest number of days to flowering in the rainy (66 DAS) and mid-rainy seasons (69 DAS). In contrast, the other 60 varieties were photosensitive varieties, and the longest number of days to flowering was found in Khao Luang, Khao Nag, Phrae Nahy Khao, 55NM S4Neu, and Leuang On (145 and 146 DAS). Thus, most local Thai varieties were photosensitive varieties. In the mid-rainy season, the rice plants were grown on 1 August 2018 (60 d before day length < 12 h). The range of days to flowering in this season was narrower than that in the rainy season, which ranged from 69–126 DAS (Fig. 2).

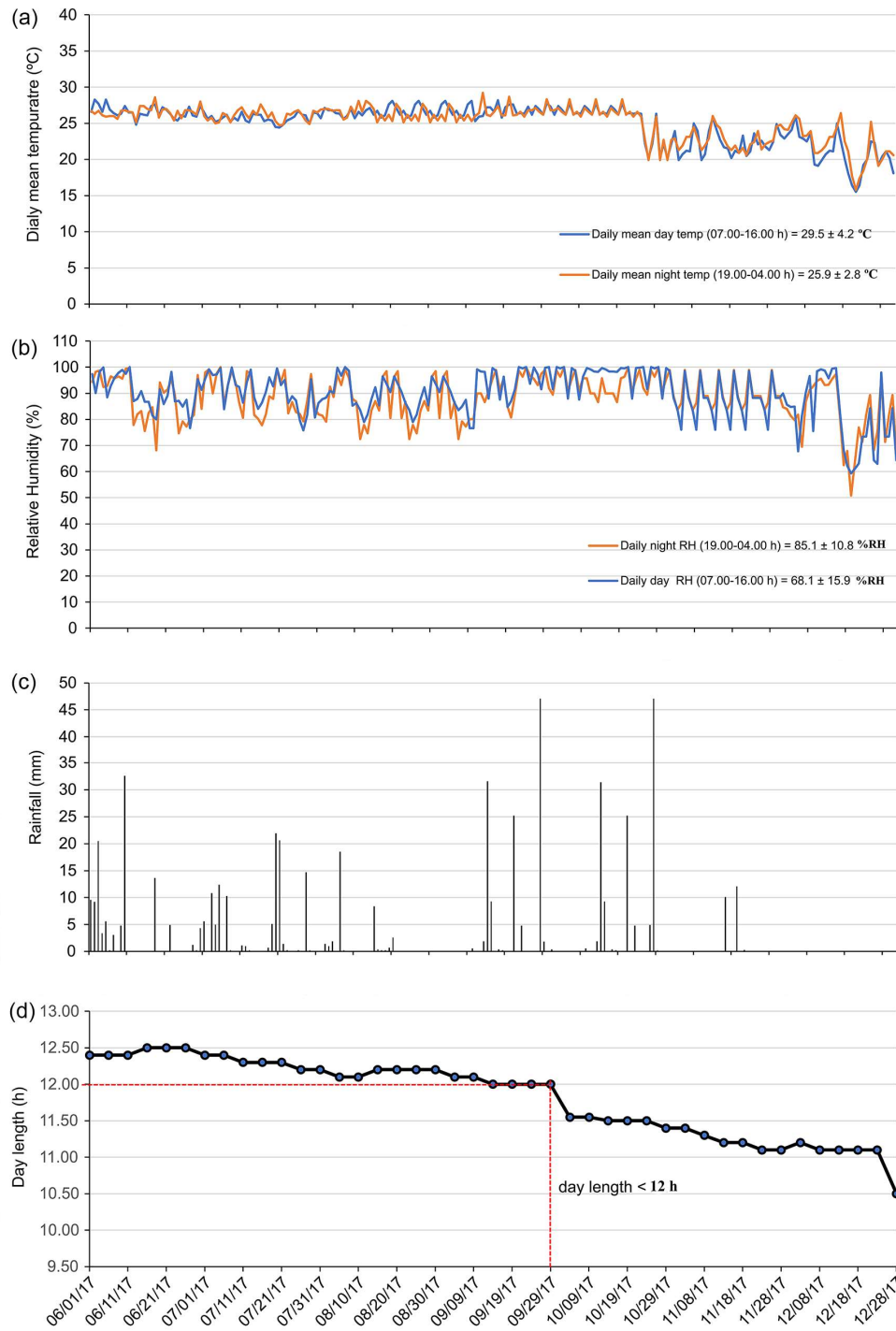


Fig. 1 Weather data, including (a) air temperature, (b) relative humidity, (c) amount of rainfall, and (d) day length, from June to December 2018.

In addition, it was confirmed that the 24 varieties were non-photosensitive varieties because the days to flowering of these varieties in the rainy season compared with the mid-rainy season were not significant. On

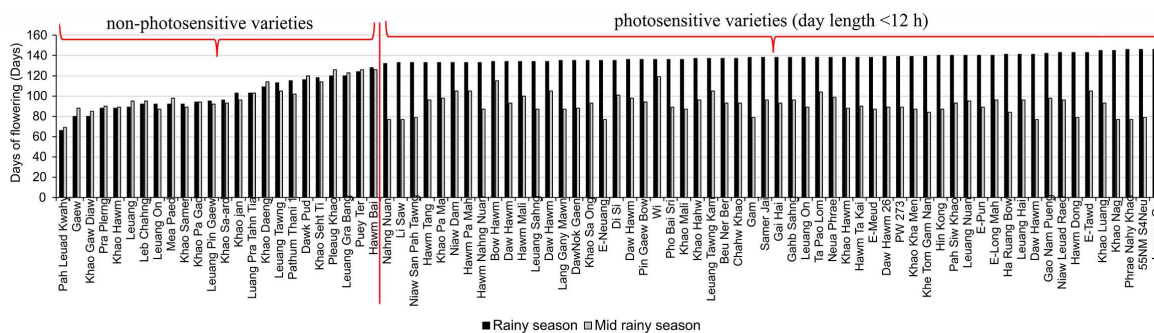
the other hand, the days of flowering of other varieties in the mid-rain season were shorter than those in the rainy season.

For plant height, most local Thai varieties were

Table 1 ANOVA, means, ranges of agronomic traits, and Shannon index of 82 local varieties grown under flooded conditions in the early rainy and rainy seasons of 2017.

Trait	Season	Local variety									
		Range	Mean	SD	LSD	%CV	G	R	S	GxS	H' index
Day of flowering (d)	Rainy	66–146	126	± 19	2.22	1.08	**	ns	**	**	0.61
	Mid rainy	69–126	94	± 13	3.21	2.06	**	ns	**	**	0.49
Plant height (cm)	Rainy	116–217	170	± 23.2	2.07	0.75	**	ns	**	**	0.50
	Mid rainy	111–210	168	± 22.9	13.31	4.91	**	ns	**	**	0.52
Culm number	Rainy	5–30	12	± 4	1.42	7.31	**	ns	ns	ns	0.51
	Mid rainy	3–28	11	± 4	0.21	1.20	**	ns	ns	ns	0.53
Panicle number	Rainy	1–18	9	± 4	0.50	3.17	**	ns	ns	ns	0.56
	Mid rainy	2–18	9	± 4	0.28	2.03	**	ns	ns	ns	0.56
Panicle length (cm)	Rainy	19–36	27.3	± 3.2	3.43	7.81	**	ns	ns	ns	0.53
	Mid rainy	19–35	27.0	± 2.8	2.95	6.86	**	ns	ns	ns	0.49
100 Grain weight (g)	Rainy	2.21–2.65	2.89	± 0.38	0.11	2.41	**	ns	ns	ns	0.50
	Mid rainy	1.63–4.03	2.85	± 0.53	0.14	3.08	**	ns	ns	ns	0.46
Grain length (mm)	Mid Rainy	4.90–10.00	7.40	± 0.80	0.05	1.02	**	–	–	–	0.23
Grain width (mm)	Mid Rainy	2.00–3.30	2.50	± 0.30	0.03	1.52	**	–	–	–	0.21
Grain length/width ratio	Mid Rainy	2.50–3.85	2.95	± 0.15	0.70	1.12	**	–	–	–	0.20

G = genotype, R = Replication, S = season, G × S = interaction between genotype and season, ns = nonsignificant, ** = significant at $p < 0.01$.

**Fig. 2** Classification of 82 local varieties according to their response to the photoperiod divided into non-photosensitive and photosensitive varieties (day length < 12 h) during the rainy season.

identified as tall to very tall plants (> 140 cm), and the other 10 varieties were identified as intermediate plants (91–140 cm). The culm number of local Thai varieties was grouped in the intermediate category (10–20 culms), followed by the low category (< 10 culm numbers) (Fig. 3A). Interestingly, the highest average culm number was 29 culms, which was found in the Hawm Ta Kai variety. In addition, this variety had the highest culm numbers in the rainy season (30 culms) and mid-rainy season (28 culms), while it produced only 18 panicles in both seasons. The panicle numbers of local varieties were identified as the same as culm numbers (intermediate and low category) (Fig. 3B). However, most varieties had a low number of panicles. In addition, when considered in each variety, it was found that the panicle number was lower than the culm

number.

The panicle length of local Thai varieties could be divided into 2 groups: long panicles (> 25 cm) and medium panicles (15–25 cm). However, most varieties had long panicles (Fig. 3C). When considering the grain shape by determining the grain length/width ratio, it was found that the grain shape could be grouped into slender, medium, bold, and round shapes. However, most varieties were classified as slender shape, followed by medium shape. In addition, the bold and short grain shapes similar to japonica type were found in 5 varieties including Leb Chahng (northern), Pleaug Khao (central), Khao Hawm (central), Chahw Khao (northeastern), and E-neuang (northeastern). All of them were upland rice varieties except Khao Hawm (Fig. 3D). However, the identification of indica

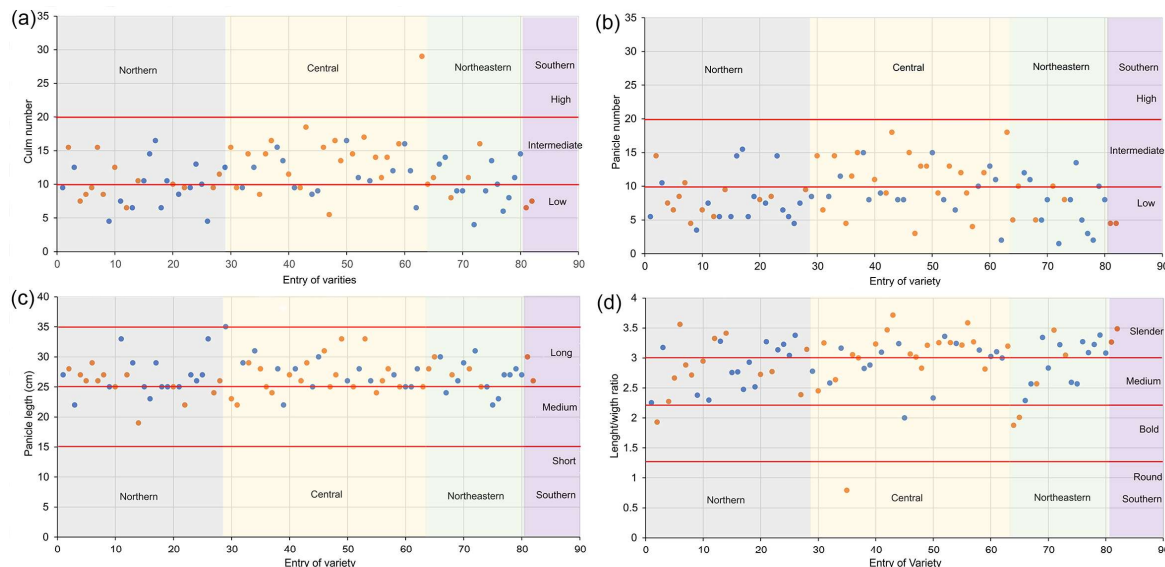


Fig. 3 The distribution of (a) culm number, (b) panicle number, (c) panicle length, and (d) grain shape of 82 local varieties. Blue and orange colors represent lowland and upland rice, respectively. Gray, yellow, green, and purple background colors represent northern, central, northeastern, and south, respectively.

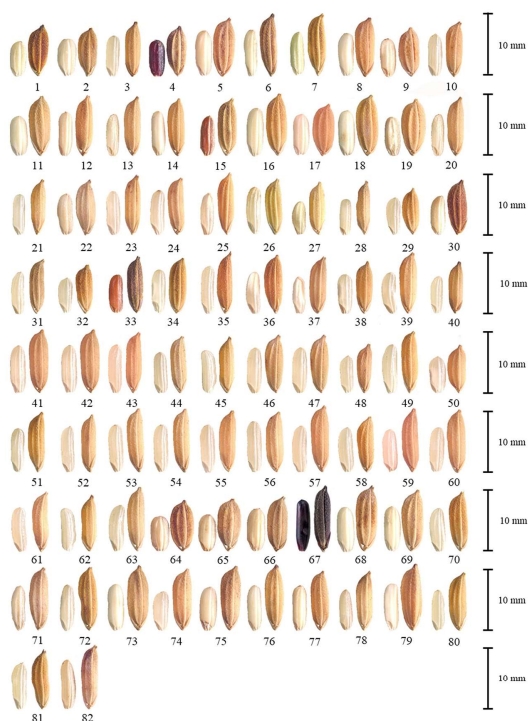


Fig. 4 Paddy grain and brown grain shapes of 82 local varieties. The numbers 1 to 82 represent the entry of varieties in Table S1.

and japonica subspecies was confirmed in genotypic analysis by SNP markers. Moreover, the husk color and

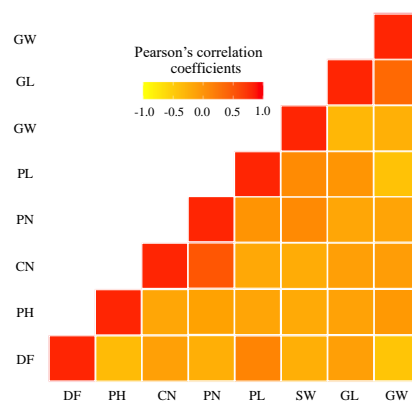


Fig. 5 The Pearson's correlation coefficients (r) among agronomic traits. DF = days of flowering, PH = plant height, CN = culm number, PN = panicle number, PL = panicle length, SW = 100 seed weight, GL = grain length, and GW = grain weight.

pericarp color of local Thai varieties varied, as shown in Fig. 4 and Table 1. Most varieties had husk straw color and pericarp white color. However, the pericarp color of 2 varieties, namely Gam and Niaw Dam, was purple, and 2 varieties, namely Niaw Leud Raed and Khao Daeng, were red.

The correlation analysis revealed that the culm numbers and panicle numbers were highly positively correlated ($r = 0.68$), while grain weight was positively correlated with panicle numbers ($r = 0.46$) and panicle length ($r = 0.45$). In addition, panicle length

was positively correlated with the day to flowering ($r = 0.41$). In terms of grain shape, the grain length and grain width were highly positively correlated ($r = 0.60$) (Fig. 5).

Phenotypic diversity

The phenotypic diversity was determined by the H' index. Among the agronomic traits of the 82 varieties, a moderate H' index was found in days of flowering, plant height, culm number, panicle number, panicle length, and grain weight, which was approximately 0.49–0.61. On the other hand, a low H' index was found for grain length (0.23), grain width (0.21), and grain length/width ratio (0.20) (Table 1).

Population structure and phylogenetic tree

Structural analysis was performed to classify the clusters of genotypes of all 82 varieties. The number of clusters was estimated based on the ΔK method [30]. The results suggested the best grouping number at $K = 5$ based on ΔK (Fig. 6A). This result suggests that the 82 varieties can be grouped into 5 subpopulations (Fig. 6B). In each group, the varieties with scores higher than 0.60 were assigned to the pure group, while those with scores lower than 0.60 were assigned to the admixture group. The results showed that most local Thai varieties in groups I, III, IV, and V consisted of non-glutinous rice. Group I consisted of 7 rice varieties from the central and northeast regions. Groups III and IV consisted of 9 and 10 rice varieties, respectively, which came from the northern and central regions. In addition, most rice varieties from group III (8 of 9 varieties) were identified as upland rice. Group V consisted of 15 rice varieties from all 4 regions. Interestingly, the 33 varieties in group II were glutinous rice (29 of 33 varieties), which came from the north, central, and northeast regions. However, the 8 varieties exhibited an admixture.

The phylogenetic tree constructed using the maximum likelihood method clustered 82 local varieties into 5 groups and one outgroup (Fig. 6C). The result of the phylogenetic tree was associated with the structural analysis. Most rice varieties in group 1 and the outgroup of the phylogenetic tree were glutinous rice and came from the north, central, and northeast regions, which is associated with group II according to the structural analysis. In addition, groups 2, 3, and 4+5 from the phylogenetic tree were associated with groups I, IV, and V from the structural analysis. However, the rice varieties of group III of the analysis were distributed to groups 1, 2, 3, and 5 of the phylogenetic tree.

For genotypic analysis, it was possible to distinguish rice varieties by region and by type of starch (glutinous and non-glutinous), but it cannot be classified according to the ecology (upland and lowland) and grain shape.

To identify subspecies between indica and japonica, all 64 SNP markers were compared with the 3K rice genome (https://snp-seek.irri.org/_snp.zul), which would consist of various sub-populations. After that SNPs were searched with allele frequencies greater than 0.6, and opposite alleles between indica and japonica groups were used (data not shown). Finally, 5 SNP markers were found which can be used to separate japonica from indica including R03017571575 (chr 3), R04005867320 (chr 4), R05003673333 (chr 5), R06001693411 (chr 6), and R12018856177 (chr 12). However, the phylogenetic tree did not separate japonica from the 82 varieties used in the experiment. Thus, it confirmed that all Thai local varieties in this experiment were identified as indica subspecies.

In this study, the 3 varieties were the same, including Khao Hawm (2 varieties), Daw Hawm (3 varieties), and Leuang On (2 varieties). When considering phenotype and genotype, it was found that 2 of the Khao Hawm varieties came from Ang Thong Province and belonged to the same structural and phylogenetic tree group, but there was a difference in days to flowering. Khao Hawm (GS No.1626) was a non-photosensitive variety, while Khao Hawm (GS No.2751) was a photosensitive variety. In addition, there were slight differences in some agronomic traits. Daw Hawm varieties had 3 GS numbers, which were identified as glutinous rice. In addition, the genotypes of these varieties were in the same group (group II), and they were identified as photosensitive varieties. However, one of them (GS No.3369) came from the northeast (Mukdahan Province), which has ecological upland rice, while the other 2 varieties came from the northern region, including Nan Province (GS No.3178) and Chiang Mai Province (GS No.5185), which had ecological characteristics of lowland and upland, respectively. For the Leuang On varieties, 2 GS numbers were in group IV (GS Nos.239 and 249), which came from northern (Chiang Mai and Uttaradit), while another one (GS No.5808) was in group V, which came from the northeast (Sa Kaeo). All of them were lowland and non-glutinous rice, but Leuang On from the northeast was identified as a non-photosensitive variety, while Leuang On from the north was identified as a photosensitive variety.

DISCUSSION

Genetic diversity is the key determinant of germplasm utilization in crop improvement. Populations with high levels of genetic variation are valuable resources for broadening the genetic base in any breeding program [31, 32]. Thus, this study evaluated the phenotypic and genotypic variation in 82 local Thai varieties from 4 regions of Thailand.

The rainy season (Jun–Oct) can be identified as the photoperiod varieties in which the day length

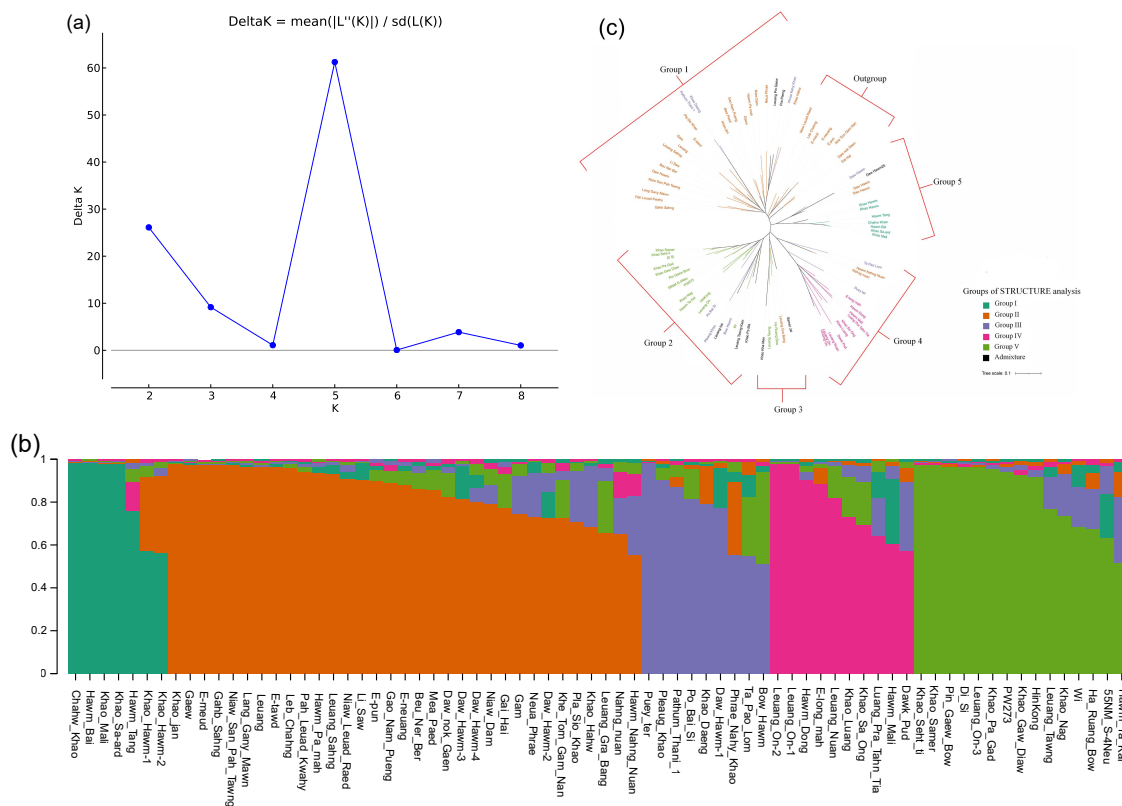


Fig. 6 Structural analysis of 82 local varieties at K = 5. (a) The average log-likelihood of the K-value against the number of K for different numbers of subpopulations (K), (b) the estimated population structure of the 82 local varieties on K = 5, and (c) phylogenetic tree illustrating the genetic relationship among the 82 local varieties. The colors in the dendrogram represent the subpopulation group of the structural analysis.

on 29 September 2018 was less than 12 h, and the induced spikelets were flowering. Thus, 24 varieties were identified as non-photosensitive varieties, and 58 varieties were identified as photosensitive varieties. This result can be confirmed in the mid-rainy season with the days to flowering of rice varieties in the non-photosensitive group being similar to those in the rainy season, while the days to flowering in the photosensitive group were shorter than those in the rainy season. Therefore, most local varieties are sensitive to daylength, and these varieties must grow in the rainy to mid-rainy season. In addition, the diversity of flowering days was also observed in both the non-photosensitive and photosensitive groups. These findings may suggest that the diversity of local rice varieties is due to the local environment in which local rice can grow and adapt to that locality [31, 32].

In addition, the other morphological traits of local varieties such as plant height, culm number, panicle number, panicle length, grain shape, husk color, and grain color were also found to be diverse and could be used to differentiate between local varieties. This result suggests that local varieties had a high genetic

variance compared to the commercial varieties that have been bred to be more genetically stable [33]. However, the name of some local varieties indicated the outstanding characteristics of that rice variety such as the varieties with the word “Khao” in Thai indicating white grain rice, “Gam” or “Dam” referring to purple color rice, “Daeng” referring to red color rice, “Niaw” referring to glutinous rice, and “Hawm” referring to aromatic rice. Therefore, the specific words that appeared in these local variety names can be used to classify the distinctive characteristics of their local varieties.

In Thailand, indica rice is the dominant rice type and is normally grown in lowland ecosystems such as the central plain and northeast of Thailand, while some indica and japonica rice is found in upland ecosystems such as the highland in northern and northeast Thailand [34]. In the pre-experiment of this study, 62 upland rice varieties were screened for ability to grow under flooded or lowland conditions (data not shown). It was found that 40 upland varieties survived and produced grain yield. These upland varieties were tested again in this study and confirmed the

previous results. This result suggests that some upland rice varieties can grow in both aerobic and anaerobic soil conditions, which may be useful in breeding rice programs for abiotic stress.

The genetic diversity of local varieties may be morphologically invisible. Thus, the genetic architecture of diverse local varieties can be precisely estimated by assessing the structure of the population using SNP markers [35]. The population structure analysis using these approaches suggested that the local varieties could be divided into 5 subpopulations and one admixture. This result was consistent with the phylogenetic tree analysis, which showed that it could be divided into 5 groups and one outgroup. However, the local varieties in each group between structure and the phylogenetic tree were slightly different.

The subpopulation from the structural analysis corresponded to glutinous rice (group II) and non-glutinous rice (group I, III, IV, and V), which were not correlated with their regions and ecologies (upland and lowland). In this study, it was found that the distribution of local varieties from each region belonged to each subpopulation. In addition, the upland and lowland varieties were also distributed among subpopulations. These results may suggest that local varieties may be exchanged by farmers among regions [36, 37]. In addition, these local varieties could not be used to classify japonica and indica groups. In contrast, Chakhonkaen et al [10] and Aeksomnuk et al [37] reported that Thai rice locals could be divided into 2 main subpopulations, corresponding to indica and japonica groups, and the majority of local varieties were identified as indica rice. However, the short grain type such as japonica was found in this study, and they were distributed in structural groups I, II, and III. However, it can be confirmed by 5 SNP markers that this short grain type was not japonica subspecies. In addition, Vejchasarn et al [34] indicated that japonica cannot be distinguished from indica by using only the grain length trait. Furthermore, Ray et al [38] reported that indica landraces had a wide range of grain length from 5.70–11.30 mm, while the range of grain length in this experiment was also varied from 4.90–10.00 mm (Table 1). Thus, this grouping can suggest that the local varieties used in the study were not representative of japonica rice.

Moreover, it should be noted that some local varieties have identical native names, which may be different or the same in their genotypes. In this research, it had 3 identical names, but there were differences in GS number, including Daw Hawm (3 varieties), Leuang On (3 varieties), and Khao Hawm (2 varieties). Among the identical names, it was found that there were different and the same group of genotypes. In addition, there were also some different phenotypes such as flowering period, type of grain, and ecology of their growth. The results of this experiment are

the same as those of Pathaichindachote et al [39] and Xiongsiyee et al [40], who reported that some rice accessions have identical primary native names but different genotypes.

CONCLUSION

The genetic diversity and population structure of 82 Thai rice locals were investigated using a set of 75 SNP markers. The information obtained from this study showed the agronomic and genotypic diversity of local Thai rice varieties. Five subpopulations were grouped that separated glutinous and non-glutinous rice. However, the source of varieties and ecology of rice were distributed in all 5 groups. In addition, the agronomic traits among these varieties were also diverse. Therefore, local Thai rice varieties may be beneficial in terms of rice germplasm that can be selected as parents in breeding programs. For example, upland rice varieties that can grow in lowland conditions may be used for drought tolerance breeding programs.

Appendix A. Supplementary data

Supplementary data associated with this article can be found at <http://dx.doi.org/10.2306/scienceasia1513-1874.2023.074>.

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Appendix A. Supplementary data

Table S1 The name, GS No., place of collection, endosperm type, ecology, husk color, and pericarp color of 82 local varieties distributed in 4 regions in Thailand.

Entry	Variety	GS No.	Place of collection		Endosperm type	Ecology	Husk color	Pericarp color
			Province	Region				
1	Pah Leuad Kwahy	137	Chiang Mai	N	Glutinous	Lowland	Brown furrow	White
2	Leb Chahng	17656	n/a	N	Glutinous	Upland	Brown spot	White
3	Bow Hawm	6480	n/a	N	Non-glutinous	Lowland	Straw	White
4	Gam	22416	Phrae	N	Glutinous	Upland	Purple furrow	Purple
5	Khao Hahw	19753	Lampang	N	Glutinous	Upland	Brown spot	White
6	Li Saw	22399	Phrae	N	Glutinous	Upland	Brown furrow	White
7	Leuang	17739	Phrae	N	Glutinous	Upland	Brown furrow	White
8	Phrae Nahy Khao	1831	Chiang Mai	N	Non-glutinous	Upland	Brown	White
9	Lang Gany Mawn	1454	Lampang	N	Glutinous	Lowland	Brown spot	White
10	Samer Jai	259	n/a	N	Non-glutinous	Upland	Straw	White
11	Khao Jan	334	n/a	N	Glutinous	Lowland	Straw	White
12	Daw Hawm 26	421	Chiang Mai	N	Glutinous	Upland	Straw	White
13	Daw Hawm	3178	Nan	N	Glutinous	Lowland	Straw	White
14	Niaw San Pah Tawng	1370	Chiang Rai	N	Glutinous	Upland	Straw	White
15	Niaw Leuad Raed	337	Chiang Mai	N	Glutinous	Lowland	Brown spot	Red
16	Gaew	1409	Lampang	N	Glutinous	Lowland	Brown spot	White
17	Gai Hai	1502	n/a	N	Glutinous	Upland	Brown	White
18	Gahb Sahng	1412	Lampang	N	Glutinous	Lowland	Brown furrow	White
19	Nahng Nuan	1425	Phrae	N	Glutinous	Lowland	Straw	White
20	Daw Hawm	5185	Chiang Mai	N	Glutinous	Upland	Straw	White
21	Pin Gaew Bow	22043	n/a	N	Non-glutinous	Lowland	Straw	White
22	Daw Nok Gaen	1468	Chiang Rai	N	Glutinous	Upland	Straw	White
23	Leuang On	239	Chiang Mai	N	Non-glutinous	Lowland	Brown spot	White
24	Mea Paed	257	Chiang Mai	N	Non-glutinous	Lowland	Straw	White
25	Leuang On	249	Uttaradit	N	Non-glutinous	Lowland	Straw	White
26	Gao Nam Pueng	1439	Lampang	N	Non-glutinous	Lowland	Brown furrow	White
27	Ha Ruang Bao	15974	n/a	N	Glutinous	Upland	Straw	White
28	Ta Pao Lom	14297	n/a	C	Non-glutinous	Upland	Straw	White
29	Khao Seht ti	9598	Ayutthaya	C	Non-glutinous	Lowland	Brown	White
30	55NM S4Neu	1503	Suphan Buri	C	Non-glutinous	Upland	Brown	White
31	Pra Plerng	11457	n/a	C	Non-glutinous	Upland	Purple furrow	White
32	Hawm Tang	1628	Ang Thong	C	Non-glutinous	Lowland Brown	furrow	White
33	Khao Daeng	6871	Uthai Thani	C	Non-glutinous	Upland	Brown spot	Red
34	Leuang Tawng Kam	9559	Nakhon Pathom	C	Non-glutinous	Lowland	Purple furrow	White
35	Pleaug Khao	19681	Phisanulok	C	Non-glutinous	Upland	Brown	White
36	Khao Luang	9169	Pathum Thani	C	Non-glutinous	Lowland	Brown	White
37	Hin Gawng	14296	Phichit	C	Non-glutinous	Upland	Straw	White
38	Puey Ter	8082	Ratchaburi	C	Non-glutinous	Upland	Brown spot	White
39	Khao Gaw Diaw	9583	Saraburi	C	Non-glutinous	Lowland	Straw	White
40	Khao Sa Ong	788	Lopburi	C	Non-glutinous	Lowland	Brown spot	White
41	Neua Phrae	8145	n/a	C	Non-glutinous	Upland	Straw	White
42	Khao Nag	7971	Nakhon Nayok	C	Non-glutinous	Lowland	Straw	White
43	Beu Ner Ber	21825	Kanchanaburi	C	Non-glutinous	Upland	Straw	White
44	Khao Pa Ma	886	n/a	C	Non-glutinous	Upland	Brown furrow	White
45	Khao Hawm	1626	Ang Thong	C	Non-glutinous	Lowland	Brown spot	White
46	Khao Samer	14474	Nakhon Pathom	C	Non-glutinous	Lowland	Brown spot	White
47	Pah Siw Khao	19683	n/a	C	Non-glutinous	Upland	Straw	White
48	Leuang Nuan	14484	n/a	C	Non-glutinous	Upland	Brown spot	White
49	Leuang Gra Bang	6390	Phisanulok	C	Non-glutinous	Upland	Straw	White
50	PW 273	667	n/a	C	Non-glutinous	Upland	Straw	White
51	Leuang Pin Gaew	23147	Suphanburi	C	Non-glutinous	Lowland	Straw	White
52	Luang Pra Tahn Tia	10858	n/a	C	Non-glutinous	Upland	Straw	White
53	Pathum Thani 1	23898	Pathum Thani	C	Non-glutinous	Lowland	Straw	White
54	Pho Bai Sri	14294	n/a	C	Non-glutinous	Upland	Straw	White

Table S1 (Continued ...)

Entry	Variety	GS No.	Place of collection		Endosperm type	Ecology	Husk color	Pericarp color
			Province	Region				
55	Hawm Mali	2747	Pathum Thani	C	Non-glutinous	Lowland	Straw	White
56	Leuang Hai	11565	Kanchanaburi	C	Non-glutinous	Upland	Straw	White
57	Hawm Bai	5459	n/a	C	Non-glutinous	Upland	Straw	White
58	Hawm Dong	11467	Saraburi	C	Non-glutinous	Upland	Straw	White
59	Khao Pa Gad	20960	Suphanburi	C	Non-glutinous	Lowland	Straw	White
60	Khao Kha Men	6925	Suphanburi	C	Non-glutinous	Upland	Straw	White
61	Khao Sa-ard	21920	Ratchaburi	C	Non-glutinous	Lowland	Straw	White
62	Khao Hawm	2751	Ang Thong	C	Non-glutinous	Lowland	Straw	White
63	Hawm Ta Kai	22042	Chainat	C	Non-glutinous	Lowland	Straw	White
64	E-neuang	4476	Udon Thani	NE	Glutinous	Upland	Brown furrow	White
65	Chahw Khao	7975	Nakhon Ratchasima	NE	Non-glutinous	Upland	Brown spot	White
66	Leuang Sahng	4009	Nakhon Phanom	NE	Glutinous	Upland	Brown spot	White
67	Niaw Dam	1872	Surin	NE	Glutinous	Lowland	Purple	Purple
68	E-pun	3327	Khon Kaen	NE	Glutinous	Lowland	Brown spot	White
69	Daw Hawm	3296	Yasothon	NE	Glutinous	Upland	Brown spot	White
70	Leuang Tawng	3249	Khon Kaen	NE	Glutinous	Lowland	Brown	White
71	E-tawd	3248	Loei	NE	Glutinous	Lowland	Straw	White
72	E-meud	4475	Udon Thani	NE	Glutinous	Upland	Brown	White
73	Khe Tom Gam Nan	7627	Kalasin	NE	Glutinous	Lowland	Straw	White
74	Di Si	15954	n/a	NE	Non-glutinous	Upland	Brown spot	White
75	Daw Hawm	3269	Mukdahan	NE	Glutinous	Lowland	Straw	White
76	Hawm Pa mah	3210	Sakon Nakhon	NE	Glutinous	Lowland	Brown spot	White
77	Hawm Nahng Nuan	3270	Nakhon Panom	NE	Glutinous	Lowland	Brown	White
78	Khao Mali	5826	Chaiyaphum	NE	Non-glutinous	Lowland	Straw	White
79	E-long mah	3255	Udon Thani	NE	Glutinous	Lowland	Brown	White
80	Leuang On	5808	Sa Kaeo	NE	Non-glutinous	Lowland	Brown	White
81	Wi	1471	n/a	S	Non-glutinous	Upland	Brown	White
82	Dawk Pud	16461	Phatthalung	S	Non-glutinous	Upland	Brown spot	White

N = northern, C = central, NE = northeastern, and S = southern.

Table S2 List of 64 SNP markers used for genotyping of 82 local varieties.

Variety/SNP marker	R01002684973	R01023762056	R01033454937	R02008313120	R02008315835	R02010864977	R03031335170	R03017286744	R03017571575
55NM S-4Neu	A/A	G/G	A/A	G/G	T/T	T/T	C/C	T/T	A/A
Beu Ner Ber	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Bow Hawm	C/C	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Chahw Khao	C/C	G/G	A/A	G/G	T/T	T/T	C/C	G/G	A/A
Daw Hawm	C/C	G/G	T/T	G/G	T/T	G/G	T/C	T/T	A/A
Daw Hawm	A/A	G/G	T/T	G/G	T/T	G/G	T/T	T/T	A/A
Daw Hawm26	C/C	A/A	T/T	G/G	T/T	G/G	-9/-9	T/T	A/A
Daw Hawm	A/A	G/G	T/T	G/G	T/T	T/T	C/C	T/T	A/A
Daw Hawm	A/A	G/G	T/T	G/G	T/T	G/G	T/T	T/T	A/A
Daw nok Gaen	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Dawk Pud	C/C	A/A	A/A	T/T	T/T	G/G	C/C	T/T	A/A
Di Si	A/A	G/G	T/T	T/T	T/T	G/G	C/C	T/T	G/G
E-long mah	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
E-meud	A/A	A/A	T/T	G/G	T/T	G/G	C/C	T/T	A/A
E-neuang	A/A	G/G	A/A	G/G	T/T	G/G	C/C	T/T	A/A
E-pun	A/A	-9/-9	T/T	G/G	T/T	-9/-9	C/C	T/T	A/A
E-tawd	A/A	A/A	A/A	G/G	T/T	G/G	C/C	T/T	A/A
Gaew	A/A	G/G	T/T	G/G	T/T	T/T	C/C	T/T	A/A
Gahb Sahng	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Gai Hai	A/A	G/G	T/T	T/T	T/T	G/G	C/C	T/T	A/A
Gam	A/A	A/A	A/A	G/G	T/T	G/G	C/C	T/T	A/A
Gao Nam Pueng	A/A	A/A	T/T	G/G	T/T	T/T	C/C	T/T	A/A
Ha Ruang Bow	A/A	A/A	T/T	G/G	T/T	T/T	C/C	T/T	A/A
Hawm Bai	C/C	G/G	A/A	G/G	T/T	T/T	C/C	G/G	A/A
Hawm Dong	C/C	-9/-9	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Hawm Mali	C/C	G/G	T/T	G/G	T/T	G/G	-9/-9	T/T	A/A
Hawm Nahng Nuan	A/A	G/G	T/T	G/G	A/A	G/G	T/T	T/T	A/A
Hawm Pa mah	C/C	G/G	T/T	G/G	T/T	T/T	C/C	T/T	A/A
Hawm Ta Kai	C/C	G/G	T/T	G/G	T/T	G/G	T/T	T/T	A/A
Hawm Tang	C/C	G/G	A/A	G/G	T/T	T/T	C/C	G/G	A/A
Hin Gawng	C/C	G/G	T/T	T/T	T/T	G/G	C/C	T/T	A/A
Khao Daeng	C/C	G/G	A/A	G/G	T/T	G/G	C/C	G/G	G/G
Khao Gaw Diaw	A/A	G/G	T/T	T/T	T/T	G/G	C/C	T/T	G/G
Khao Hahw	C/C	G/G	A/A	G/G	T/T	T/T	T/T	T/T	A/A
Khao Hawm	C/C	G/G	A/A	G/G	T/T	G/G	C/C	T/T	A/A
Khao Hawm	C/C	G/G	A/A	G/G	T/T	G/G	C/C	T/T	A/A
Khao jan	A/A	G/G	T/T	G/G	T/T	T/T	C/C	T/T	A/A
Khao Kha Men	A/A	G/G	A/A	T/T	A/A	G/G	C/C	G/G	A/A
Khao Luang	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Khao Mali	C/C	A/A	A/A	G/G	T/T	T/T	C/C	G/G	A/A
Khao Nag	C/C	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Khao Pa Gad	A/A	G/G	T/T	T/T	T/T	G/G	C/C	T/T	A/A
Khao Pa Ma	-9/-9	-9/-9	T/T	G/G	T/T	T/T	C/C	T/T	A/A
Khao Sa Ong	A/A	G/G	T/T	G/G	T/T	G/G	C/C	G/G	A/A
Khao Sa-ard	C/C	A/A	A/A	G/G	T/T	T/T	C/C	G/G	A/A
Khao Samer	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	G/G
Khao Seht ti	A/A	G/G	T/T	T/T	T/T	G/G	C/C	T/T	G/G
Khe Tom Gam Nan	A/A	G/G	T/T	G/G	A/A	T/T	C/C	T/T	A/A
Lang Gany Mawn	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Leb Chahng	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Leuang	A/A	A/A	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Leuang Gra Bang	A/A	G/G	T/T	G/G	T/T	T/T	C/C	T/T	A/A
Leuang hai	C/C	G/G	A/A	G/G	T/T	G/G	C/C	T/T	A/A
Leuang Nuan	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	G/G
Leuang On	A/A	G/G	T/T	T/T	T/T	G/G	C/C	T/T	G/G
Leuang On	A/A	G/G	T/T	T/T	T/T	G/G	C/C	T/T	G/G
Leuang On	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Leuang Pin Gaew	C/C	G/G	A/A	G/G	T/T	G/G	C/C	T/T	G/G
Leuang Sahng	A/A	A/A	A/A	G/G	T/T	T/T	C/C	T/T	A/A
Leuang Tawng	C/C	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Leuang Tawng Kam	C/C	G/G	T/T	G/G	T/T	T/T	C/C	T/T	A/A
Li Saw	A/A	A/A	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Luang Pra Tahn Tia	C/C	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Mea Paed	A/A	A/A	T/T	G/G	T/T	T/T	C/C	T/T	A/A
Nahng nuan	A/A	G/G	T/T	G/G	T/T	G/G	T/T	T/T	A/A
Neua Phrae	C/C	G/G	T/T	G/G	T/T	T/T	T/T	T/T	A/A
Niaw Dam	A/A	G/G	A/A	G/G	T/T	T/T	C/C	T/T	A/A
Niaw Leuad Raed	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Niaw San Pah Tawng	A/A	G/G	T/T	G/G	T/T	T/T	C/C	T/T	A/A
Pah Leuad Kwahy	A/A	A/A	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Pathum Thani 1	A/A	G/G	A/A	G/G	T/T	G/G	C/C	G/G	G/G
Pho Bai Si	C/C	C/C	G/G	A/A	-9/-9	C/C	T/T	A/A	T/T
Phrae Nahy Khao	C/C	G/G	A/A	G/G	T/T	G/G	T/T	T/T	A/A
Pin Gaew Bow	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Pla Siw Khao	A/A	A/A	T/T	G/G	T/T	G/G	T/T	T/T	A/A
Pleaug Khao	C/C	G/G	A/A	G/G	T/T	G/G	T/T	T/T	A/A
Pra Plerng	C/C	G/G	A/A	G/G	T/T	G/G	C/C	T/T	A/A
Puey ter	-9/-9	G/G	T/T	T/G	A/A	G/G	T/C	G/G	A/G
PW273	A/A	G/G	T/T	G/G	T/T	G/G	C/C	T/T	A/A
Samer Jai	A/A	G/G	T/T	G/G	T/T	T/T	C/C	T/T	A/A
Ta Pao Lom	C/C	A/A	G/G	A/A	T/T	C/C	T/T	A/A	T/T
Wi	A/A	G/G	A/A	T/T	T/T	T/T	C/C	T/T	A/A

Table S2 (Continued ...)

Variety/SNP marker	R03031437173	R03016733359	R04016214690	R04016214692	R04016218749	R04006451939	R04022184296	R04006968050	R04023175725
55NM S-4Neu	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	-9/-9	-9/-9	T/T
Beu Ner Ber	C/C	A/A	-9/-9	CA/CA	T/T	C/C	A/A	A/A	T/T
Bow Hawm	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	T/T	A/A	A/A	T/T
Chahw Khao	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	A/A	T/T
Daw Hawm	C/C	A/A	-9/-9	TG/TG	G/G	T/T	A/A	A/A	T/T
Daw Hawm	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	A/A	T/T
Daw Hawm26	A/A	A/A	-/TTTATGCCTCTGGTGTGACCA	-9/-9	G/G	C/C	G/G	G/G	C/C
Daw Hawm	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Daw Hawm	C/C	A/A	-9/-9	TG/TG	G/G	C/C	A/A	A/A	T/T
Daw nok Gaen	C/C	A/A	-9/-9	TG/TG	G/G	C/C	A/A	A/A	T/T
Dawk Pud	C/C	C/C	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	T/T	G/G	A/A	C/C
Di Si	C/C	A/A	-9/-9	TG/TG	G/G	C/C	G/G	A/A	T/T
E-long mah	C/C	A/A	-9/-9	TG/TG	G/G	C/C	A/A	A/A	T/T
E-meud	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
E-neuang	C/C	A/A	-9/-9	TG/TG	G/G	-9/-9	G/G	A/A	T/T
E-pun	C/C	A/A	-9/-9	TG/TG	G/G	C/C	A/A	G/G	T/T
E-tawd	C/C	A/A	TTTATGCCTCTGGTGTGACCA/ TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Gaew	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Gahb Sahng	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	G/G	A/A	C/C
Gai Hai	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	G/G	A/A	T/T
Gam	C/C	C/C	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	G/G	T/T
Gao Nam Pueng	C/C	A/A	TTTATGCCTCTGGTGTGACCA/ TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Ha Ruang Bow	C/C	A/A	-9/-9	TG/TG	G/G	C/C	G/G	G/G	T/T
Hawm Bai	C/C	A/A	-/-	TG/TG	G/G	C/C	A/A	A/A	T/T
Hawm Dong	C/C	A/A	-9/-9	TG/TG	G/G	C/C	A/A	G/G	T/T
Hawm Mali	C/C	-9/-9	-9/-9	TG/TG	G/G	T/T	A/A	A/A	T/T
Hawm Nahng Nuan	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	A/A	C/C
Hawm Pa mah	C/C	A/A	TTTATGCCTCTGGTGTGACCA/ TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Hawm Ta Kai	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	G/G	A/A	C/C
Hawm Tang	C/C	A/A	-9/-9	TG/TG	G/G	C/C	A/A	A/A	T/T
Hin Gawng	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	A/A	T/T
Khao Daeng	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Khao Gaw Diaw	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	A/A	T/T
Khao Hahw	A/A	A/A	TTTATGCCTCTGGTGTGACCA/ TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	T/T	A/A	A/A	T/T
Khao Hawm	C/C	A/A	-9/-9	TG/TG	G/G	C/C	A/A	A/A	T/T
Khao Hawm	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	A/A	T/T
Khao jan	C/C	C/C	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Khao Kha Men	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	G/G	G/G	T/T
Khao Luang	C/C	A/A	-9/-9	TG/TG	G/G	C/C	G/G	G/G	T/T
Khao Mali	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	A/A	T/T
Khao Nag	C/C	C/C	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	G/G	A/A	C/C
Khao Pa Gad	C/C	C/C	-9/-9	TG/TG	G/G	C/C	G/G	A/A	T/T
Khao Pa Ma	C/C	C/C	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	G/G	A/A	-9/-9
Khao Sa Ong	C/C	A/A	-9/-9	TG/TG	G/G	C/C	G/G	A/A	T/T
Khao Sa-ard	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	A/A	T/T
Khao Samer	C/C	A/A	-9/-9	TG/TG	G/G	C/C	G/G	A/A	T/T
Khao Seht ti	C/C	C/C	-9/-9	TG/TG	G/G	C/C	G/G	A/A	T/T
Khe Tom Gam Nan	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	G/G	T/T
Lang Gany Mawn	C/C	C/C	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	G/G	A/A	C/C
Leb Chahng	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Leuang	C/C	A/A	-9/-9	CA/CA	T/T	C/C	A/A	A/A	T/T
Leuang Gra Bang	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	G/G	T/T
Leuang hai	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	G/G	A/A	T/T
Leuang Nuan	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	G/G	A/A	T/T
Leuang On	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	G/G	A/A	T/T
Leuang On	C/C	A/A	-9/-9	TG/TG	G/G	C/C	G/G	A/A	T/T
Leuang On	C/C	A/A	-9/-9	TG/TG	G/G	C/C	A/A	A/A	T/T
Leuang Pin Gaew	C/C	A/A	TTTATGCCTCTGGTGTGACCA/ TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	T/T	G/G	A/A	T/T
Leuang Sahng	C/C	C/C	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Leuang Tawng	C/C	A/A	-9/-9	TG/TG	G/G	C/C	A/A	G/G	T/T
Leuang Tawng Kam	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	C/C
Li Saw	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	G/G	A/A	T/T
Luang Pra Tahn Tia	C/C	A/A	-9/-9	TG/TG	G/G	T/T	A/A	A/A	T/T
Mea Paed	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	-9/-9	C/C	A/A	A/A	T/T
Nahng nuan	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	A/A	C/C
Neua Phrae	A/A	A/A	-9/-9	CA/CA	T/T	T/T	A/A	A/A	T/T
Niaw Dam	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	G/G	A/A	T/T
Niaw Leuad Raed	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	T/T	A/A	A/A	T/T
Niaw San Pah Tawng	C/C	A/A	TTTATGCCTCTGGTGTGACCA/ TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Pah Leuad Kwahy	C/C	C/C	TTTATGCCTCTGGTGTGACCA/ TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	G/G	A/A	C/C
Pathum Thani 1	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Pho Bai Si	T/T	G/G	T/T	C/C	C/C	T/T	A/A	C/C	A/A
Phrae Nahy Khao	A/A	A/A	TTTATGCCTCTGGTGTGACCA/ TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Pin Gaew Bow	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	A/A	A/A	T/T
Pla Siw Khao	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	G/G	A/A	T/T
Pleaug Khao	A/A	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	A/A	A/A	T/T
Pra Plerng	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	CA/CA	T/T	C/C	G/G	A/A	T/T
Puey ter	C/C	A/C	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/T	T/T	G/A	A/A	T/T
PW273	C/C	-9/-9	-9/-9	TG/TG	G/G	C/C	-9/-9	-9/-9	T/T
Samer Jai	C/C	A/A	-/TTTATGCCTCTGGTGTGACCA	TG/TG	G/G	C/C	G/G	A/A	T/T
Ta Pao Lom	A/A	G/G	T/T	C/C	T/T	G/G	A/A	C/C	A/A
Wi	C/C	A/A	-9/-9	TG/TG	G/G	C/C	A/A	A/A	T/T

Table S2 (Continued ...)

Variety/SNP marker	R04023172729	R04005867320	R04001019335	R04011087541	R04011803874	R05019155333	R05019155705	R05003673333	R05023218617	R06006752886
55NM S-4Neu	G/G	T/T	A/A	G/G	T/T	G/G	G/G	C/C	A/A	-9/-9
Beu Ner Ber	G/G	T/T	A/A	T/T	A/A	A/A	T/T	C/C	A/A	TT/TT
Bow Hawm	G/G	T/T	-9/-9	G/G	T/T	A/A	T/T	C/C	A/A	GC/GC
Chahw Khao	G/G	G/G	G/G	G/G	A/A	A/A	T/T	C/C	C/C	TT/TT
Daw Hawm	G/G	T/T	G/G	G/G	T/T	A/A	T/T	C/C	C/C	TT/TT
Daw Hawm	G/G	G/G	A/A	A/A	T/T	A/A	T/T	C/C	C/C	TT/TT
Daw Hawm26	T/T	G/G	G/G	-9/-9	A/A	A/A	T/T	C/C	-9/-9	TT/TT
Daw Hawm	G/G	G/G	A/A	G/G	T/T	A/A	T/T	T/T	A/A	TT/TT
Daw Hawm	G/G	G/G	A/A	G/G	T/T	A/A	T/T	C/C	C/C	TT/TT
Daw nok Gaen	G/G	T/T	A/A	T/T	A/A	A/A	T/T	C/C	C/C	TT/TT
Dawk Pud	T/T	G/G	A/A	G/G	A/A	G/G	G/G	C/C	C/C	GC/GC
Di Si	G/G	G/G	G/G	G/G	T/T	G/G	G/G	C/C	C/C	GC/GC
E-long mah	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
E-meud	G/G	T/T	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
E-neuang	G/G	G/G	A/A	G/G	T/T	A/A	T/T	T/T	C/C	TT/TT
E-pun	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
E-tawd	G/G	G/G	A/A	G/G	-9/-9	A/A	T/T	T/T	C/C	TT/TT
Gaew	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Gahb Sahng	T/T	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Gai Hai	G/G	T/T	A/A	T/T	A/A	A/A	T/T	C/C	C/C	TT/TT
Gam	G/G	T/T	A/A	G/G	T/T	A/A	T/T	C/C	C/C	TT/TT
Gao Nam Pueng	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Ha Ruang Bow	G/G	T/T	A/A	G/G	T/T	A/A	T/T	C/C	C/C	GC/GC
Hawm Bai	G/G	G/G	G/G	G/G	A/A	A/A	T/T	C/C	C/C	TT/TT
Hawm Dong	G/G	T/T	A/A	G/G	T/T	A/A	T/T	C/C	C/C	TT/TT
Hawm Mali	G/G	T/T	-9/-9	G/G	T/T	A/A	T/T	C/C	A/A	TT/TT
Hawm Nahng Nuan	T/T	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Hawm Pa mah	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Hawm Ta Kai	T/T	G/G	A/A	G/G	T/T	A/A	T/T	C/C	C/C	TT/TT
Hawm Tang	G/G	G/G	G/G	G/G	A/A	A/A	T/T	C/C	C/C	TT/TT
Hin Gawng	G/G	G/G	A/A	G/G	T/T	A/A	T/T	C/C	C/C	GC/GC
Khao Daeng	G/G	T/T	-9/-9	G/G	T/T	A/A	G/G	T/T	A/A	TT/TT
Khao Gaw Diaw	G/G	G/G	A/A	T/T	A/A	G/G	G/G	T/T	C/C	GC/GC
Khao Hahw	G/G	T/T	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Khao Hawm	G/G	G/G	G/G	G/G	A/A	G/G	G/G	C/C	C/C	TT/TT
Khao Hawm	G/G	G/G	G/G	G/G	A/A	G/G	G/G	C/C	C/C	TT/TT
Khao jan	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Khao Kha Men	G/G	T/T	A/A	G/G	T/T	A/A	T/T	C/C	C/C	TT/TT
Khao Luang	G/G	T/T	A/A	G/G	T/T	A/A	T/T	C/C	A/A	GC/GC
Khao Mali	G/G	G/G	G/G	G/G	A/A	A/A	T/T	C/C	C/C	TT/TT
Khao Nag	T/T	G/G	A/A	G/G	T/T	A/A	T/T	C/C	A/A	GC/GC
Khao Pa Gad	G/G	G/G	G/G	T/T	A/A	G/G	G/G	C/C	C/C	GC/GC
Khao Pa Ma	G/G	G/G	-9/-9	T/T	A/A	A/A	T/T	C/C	C/C	GC/GC
Khao Sa Ong	G/G	G/G	A/A	T/T	A/A	A/A	T/T	T/T	C/C	GC/GC
Khao Sa-ard	G/G	G/G	G/G	G/G	A/A	A/A	T/T	C/C	C/C	TT/TT
Khao Samer	G/G	G/G	A/A	G/G	T/T	A/A	T/T	T/T	C/C	GC/GC
Khao Seht ti	G/G	G/G	A/A	G/G	T/T	A/A	T/T	T/T	C/C	GC/GC
Khe Tom Gam Nan	G/G	G/G	A/A	G/G	T/T	G/G	G/G	-9/-9	C/C	TT/TT
Lang Gany Mawn	T/T	G/G	A/A	G/G	T/T	A/A	T/T	C/C	C/C	TT/TT
Leb Chahng	G/G	G/G	A/A	T/T	A/A	G/G	G/G	C/C	C/C	TT/TT
Leuang	G/G	T/T	A/A	G/G	T/T	A/A	T/T	C/C	C/C	TT/TT
Leuang Gra Bang	G/G	T/T	A/A	G/G	T/T	A/A	T/T	C/C	C/C	TT/TT
Leuang hai	G/G	G/G	G/G	G/G	A/A	A/A	T/T	C/C	C/C	GC/GC
Leuang Nuan	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	GC/GC
Leuang On	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Leuang On	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Leuang On	G/G	G/G	A/A	T/T	A/A	A/A	T/T	C/C	C/C	GC/GC
Leuang Pin Gaew	G/G	T/T	G/G	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Leuang Sahng	G/G	T/T	A/A	G/G	T/T	A/A	T/T	C/C	C/C	TT/TT
Leuang Tawng	G/G	T/T	A/A	G/G	T/T	A/A	T/T	C/C	A/A	GC/GC
Leuang Tawng Kam	T/T	G/G	A/A	G/G	T/T	A/A	T/T	T/T	A/A	GC/GC
Li Saw	G/G	G/G	A/A	T/T	A/A	A/A	T/T	C/C	C/C	TT/TT
Luang Pra Tahn Tia	G/G	T/T	G/G	G/G	T/T	A/A	T/T	C/C	A/A	GC/GC
Mea Paed	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Nahng nuan	T/T	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Neua Phrae	G/G	-9/-9	A/A	G/G	T/T	G/G	G/G	C/C	A/A	TT/TT
Niaw Dam	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Niaw Leuad Raed	G/G	G/G	G/G	G/G	T/T	A/A	T/T	C/C	A/A	TT/TT
Niaw San Pah Tawng	G/G	T/T	A/A	G/G	T/T	A/A	T/T	C/C	C/C	TT/TT
Pah Leuad Kwahy	T/T	T/T	A/A	G/G	T/T	A/A	T/T	C/C	C/C	TT/TT
Pathum Thani 1	G/G	T/T	A/A	G/G	T/T	A/A	G/G	T/T	A/A	GC/GC
Pho Bai Si	CA/CA	T/T	T/T	G/A	A/A	T/T	G/G	T/T	G/G	G/G
Phrae Nahy Khao	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Pin Gaew Bow	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	GC/GC
Pla Siw Khao	G/G	G/G	A/A	T/T	A/A	A/A	T/T	C/C	A/A	TT/TT
Pleaug Khao	G/G	G/G	A/A	T/T	A/A	A/A	T/T	C/C	A/A	GC/GC
Pra Plerng	G/G	G/G	A/A	T/T	A/A	G/G	G/G	C/C	C/C	TT/TT
Puey ter	-9/-9	-9/-9	-9/-9	T/T	T/T	G/A	T/T	C/C	A/A	TT/GC
PW273	G/G	T/T	A/A	G/G	T/T	G/G	G/G	C/C	A/A	-9/-9
Samer Jai	G/G	G/G	A/A	G/G	T/T	G/G	G/G	C/C	C/C	TT/TT
Ta Pao Lom	TG/TG	G/G	C/C	A/A	A/A	C/C	T/T	G/G	A/A	T/T
Wi	G/G	T/T	A/A	T/T	A/A	A/A	T/T	T/T	A/A	GC/GC

Table S2 (Continued ...)

Variety/SNP marker	R06001765760	R06001768997	R06001693194	R06001693411	R06001768006	R06001768724	R06006752887	R07020013105	R07027746661
55NM S-4Neu	G/G	C/C	A/A	C/C	C/C	C/C	G/G	T/T	G/G
Beu Ner Ber	T/T	C/C	G/G	A/A	A/A	C/C	G/G	T/T	C/C
Bow Hawm	G/G	T/T	A/A	C/C	A/A	C/C	G/G	T/T	G/G
Chahw Khao	T/T	C/C	G/G	A/A	A/A	C/C	G/G	T/T	G/G
Daw Hawm	T/T	C/C	A/G	C/A	A/A	C/C	T/T	T/T	G/G
Daw Hawm	T/T	C/C	A/A	C/C	A/A	C/C	T/T	G/G	G/G
Daw Hawm26	T/T	C/C	-9/-9	C/C	A/A	C/C	-9/-9	T/T	G/G
Daw Hawm	T/T	C/C	G/G	A/A	A/A	C/C	T/T	G/G	G/G
Daw Hawm	T/T	C/C	A/A	C/C	A/A	C/C	T/T	G/G	G/G
Daw nok Gaen	G/G	T/T	G/G	A/A	A/A	C/C	T/T	T/T	C/C
Dawk Pud	G/G	T/T	A/A	C/C	A/A	C/C	G/G	G/G	G/G
Di Si	G/G	C/C	A/A	C/C	C/C	T/T	G/G	G/G	G/G
E-long mah	G/G	T/T	A/A	C/C	A/A	C/C	T/T	T/T	G/G
E-meud	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	C/C
E-neuang	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	C/C
E-pun	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	G/G
E-tawd	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	G/G
Gaew	T/T	C/C	G/G	A/A	A/A	C/C	T/T	G/G	C/C
Gahb Sahng	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	C/C
Gai Hai	T/T	C/C	G/G	A/A	A/A	C/C	T/T	G/G	C/C
Gam	T/T	C/C	A/A	C/C	A/A	C/C	T/T	T/T	C/C
Gao Nam Pueng	G/G	T/T	A/A	C/C	A/A	C/C	T/T	T/T	G/G
Ha Ruang Bow	G/G	T/T	A/A	C/C	A/A	C/C	G/G	T/T	G/G
Hawm Bai	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	G/G
Hawm Dong	G/G	T/T	A/A	C/C	A/A	C/C	T/T	G/G	G/G
Hawm Mali	T/T	-9/-9	G/G	A/A	A/A	C/C	T/T	T/T	G/G
Hawm Nahng Nuan	T/T	C/C	G/G	A/A	A/A	C/C	T/T	G/G	G/G
Hawm Pa mah	T/T	C/C	G/G	A/A	A/A	C/C	T/T	G/G	C/C
Hawm Ta Kai	G/G	C/C	A/A	C/C	C/C	C/C	G/G	G/G	C/C
Hawm Tang	G/G	C/C	G/G	A/A	A/A	C/C	T/T	G/G	G/G
Hin Gawng	G/G	T/T	A/A	C/C	A/A	C/C	G/G	T/T	C/C
Khao Daeng	T/T	C/C	G/G	A/A	A/A	T/T	G/G	G/G	C/C
Khao Gaw Diaw	G/G	T/T	A/A	C/C	A/A	C/C	G/G	T/T	G/G
Khao Hahw	T/T	C/C	G/G	A/A	A/A	C/C	T/T	G/G	C/C
Khao Hawm	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	G/G
Khao Hawm	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	G/G
Khao jan	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	C/C
Khao Kha Men	G/G	T/T	A/A	C/C	A/A	C/C	G/G	G/G	G/G
Khao Luang	G/G	T/T	A/A	C/C	A/A	C/C	G/G	T/T	C/C
Khao Mali	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	G/G
Khao Nag	G/G	C/C	A/A	C/C	C/C	C/C	G/G	T/T	C/C
Khao Pa Gad	G/G	T/T	A/A	C/C	A/A	C/C	G/G	G/G	C/C
Khao Pa Ma	G/G	T/T	A/A	C/C	A/A	C/C	G/G	G/G	G/G
Khao Sa Ong	G/G	T/T	A/A	C/C	A/A	C/C	G/G	G/G	G/G
Khao Sa-ard	T/T	C/C	G/G	A/A	A/A	C/C	G/G	T/T	G/G
Khao Samer	G/G	C/C	A/A	C/C	C/C	T/T	G/G	G/G	G/G
Khao Seht ti	G/G	C/C	A/A	C/C	C/C	T/T	G/G	G/G	G/G
Khe Tom Gam Nan	T/T	C/C	G/G	A/A	C/C	C/C	T/T	T/T	G/G
Lang Gany Mawn	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	C/C
Leb Chahng	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	C/C
Leuang	T/T	C/C	A/A	C/C	A/A	C/C	T/T	T/T	C/C
Leuang Gra Bang	G/G	T/T	A/A	C/C	A/A	C/C	T/T	T/T	C/C
Leuang hai	G/G	T/T	A/A	C/C	A/A	C/C	G/G	T/T	G/G
Leuang Nuan	G/G	C/C	A/A	C/C	C/C	T/T	G/G	G/G	C/C
Leuang On	G/G	C/C	A/A	C/C	C/C	C/C	T/T	G/G	G/G
Leuang On	G/G	C/C	A/A	C/C	C/C	C/C	T/T	G/G	G/G
Leuang On	G/G	C/C	A/A	C/C	C/C	C/C	G/G	T/T	C/C
Leuang Pin Gaew	T/T	C/C	G/G	A/A	A/A	C/C	T/T	G/G	G/G
Leuang Sahng	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	G/G
Leuang Tawng	G/G	T/T	A/A	C/C	A/A	C/C	G/G	G/G	G/G
Leuang Tawng Kam	G/G	T/T	A/A	C/C	A/A	C/C	G/G	T/T	G/G
Li Saw	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	C/C
Luang Pra Tahn Tia	G/G	T/T	A/A	C/C	A/A	C/C	G/G	T/T	G/G
Mea Paed	G/G	T/T	G/G	A/A	A/A	C/C	T/T	T/T	C/C
Nahng nuan	T/T	C/C	G/G	A/A	A/A	C/C	T/T	G/G	G/G
Neua Phrae	T/T	C/C	G/G	A/A	A/A	C/C	G/G	T/T	G/G
Niaw Dam	G/G	T/T	A/A	C/C	A/A	C/C	T/T	G/G	C/C
Niaw Leuad Raed	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	G/G
Niaw San Pah Tawng	T/T	C/C	G/G	A/A	A/A	C/C	T/T	T/T	C/C
Pah Leuad Kwahy	T/T	C/C	A/A	C/C	A/A	C/C	T/T	T/T	G/G
Pathum Thani 1	G/G	C/C	G/G	C/C	C/C	T/T	G/G	G/G	C/C
Pho Bai Si	T/T	A/A	T/T	G/G	T/T	C/C	C/C	C/C	TT/GC
Phrae Nahy Khao	G/G	C/C	A/A	C/C	A/A	C/C	T/T	G/G	C/C
Pin Gaew Bow	G/G	C/C	A/A	C/C	C/C	C/C	G/G	T/T	G/G
Pla Siv Khao	T/T	C/C	G/G	A/A	A/A	C/C	G/G	G/G	C/C
Pleaug Khao	G/G	T/T	A/A	C/C	A/A	C/C	G/G	T/T	G/G
Pra Plerng	T/T	C/C	G/G	A/A	A/A	C/C	G/G	G/G	G/G
Puey ter	T/T	C/T	A/G	C/A	A/A	C/C	G/G	T/T	G/C
PW273	G/G	C/C	A/A	C/C	C/C	C/C	G/G	T/T	G/G
Samer Jai	G/G	T/T	A/A	C/C	A/A	C/C	T/T	G/G	G/G
Ta Pao Lom	A/A	A/A	T/T	G/G	T/T	C/C	C/C	C/C	GC/GC
Wi	G/G	T/T	A/A	C/C	A/A	C/C	G/G	T/T	G/G

Table S2 (Continued ...)

Variety/SNP marker	R07005873563	R07006780119	R07020826100	R08020382861	R08003007900	R08027176617	R08027943348	R08002269285	R08027057202
55NM S-4Neu	A/A	G/G	G/G	ATTATGGC/ATTATGGC	C/C	A/A	A/A	C/C	G/G
Beu Ner Ber	A/A	A/A	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	G/G	G/G
Bow Hawm	A/A	-9/-9	G/T	ATTATGGC/ATTATGGC	C/C	A/A	A/A	C/C	G/G
Chahw Khao	A/A	A/A	G/G	-9/-9	C/C	A/A	A/A	C/C	G/G
Daw Hawm	A/A	-9/-9	G/G	-/-	C/C	A/A	A/A	C/C	A/A
Daw Hawm	A/A	-9/-9	G/G	-/-	C/C	A/A	A/A	G/G	A/A
Daw Hawm26	A/A	-9/-9	G/G	-/-	-9/-9	A/A	A/A	G/G	A/A
Daw Hawm	A/A	-9/-9	G/G	-/-	C/C	A/A	G/G	G/G	G/G
Daw Hawm	A/A	A/A	G/G	-9/-9	C/C	A/A	A/A	G/G	A/A
Daw nok Gaen	G/G	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	G/G	G/G
Dawk Pud	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	A/A	G/G	C/C	G/G
Di Si	A/A	A/A	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
E-long mah	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	G/G	G/G
E-meud	A/A	A/A	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
E-neuang	G/G	A/A	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
E-pun	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	A/A
E-tawd	G/G	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	A/A	G/G	G/G	G/G
Gaew	G/G	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	A/A	G/G	G/G	G/G
Gahb Sahng	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	A/A	G/G	G/G	G/G
Gai Hai	A/A	A/A	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	G/G	G/G
Gam	G/G	A/A	G/G	ATTATGGC/ATTATGGC	G/G	C/C	G/G	G/G	A/A
Gao Nam Pueng	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	G/G	G/G
Ha Ruang Bow	A/A	A/A	G/G	ATTATGGC/ATTATGGC	C/C	A/A	G/G	C/C	G/G
Hawm Bai	A/A	A/A	G/G	-/-	C/C	A/A	A/A	C/C	G/G
Hawm Dong	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Hawm Mali	A/A	-9/-9	G/G	-/-	G/G	A/A	A/A	C/C	G/G
Hawm Nahng Nuan	A/A	-9/-9	T/T	-/-	G/G	A/A	G/G	C/C	G/G
Hawm Pa mah	A/A	-9/-9	G/G	-/-	G/G	C/C	G/G	G/G	G/G
Hawm Ta Kai	A/A	A/A	G/G	-/-	G/G	C/C	G/G	C/C	G/G
Hawm Tang	A/A	-9/-9	T/T	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Hin Gawng	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Khao Daeng	G/G	G/G	G/G	ATTATGGC/ATTATGGC	C/C	C/C	G/G	G/G	G/G
Khao Gaw Diaw	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	G/G	G/G
Khao Hahw	A/A	A/A	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	G/G	G/G
Khao Hawm	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	A/A	G/G	C/C	G/G
Khao Hawm	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	A/A	G/G	C/C	G/G
Khao jan	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	G/G	G/G
Khao Kha Men	A/A	A/A	G/G	-9/-9	G/G	A/A	G/G	G/G	G/G
Khao Luang	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	C/C	G/G	C/C	G/G
Khao Mali	A/A	G/G	G/G	-/-	C/C	A/A	A/A	C/C	G/G
Khao Nag	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	A/A	G/G	C/C	G/G
Khao Pa Gad	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Khao Pa Ma	A/A	G/G	T/T	ATTATGGC/ATTATGGC	C/C	A/A	G/G	G/G	A/A
Khao Sa Ong	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	C/C	G/G	G/G	G/G
Khao Sa-ard	A/A	A/A	G/G	-/-	C/C	A/A	A/A	C/C	G/G
Khao Samer	A/A	A/A	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Khao Seht ti	A/A	A/A	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Khe Tom Gam Nan	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	A/A
Lang Gany Mawn	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	C/C	G/G	G/G	G/G
Leb Chahng	A/A	A/A	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Leuang	G/G	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	C/C	G/G	G/G	A/A
Leuang Gra Bang	A/A	A/A	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	G/G	G/G
Leuang hai	A/A	-9/-9	G/G	-/-	C/C	A/A	A/A	C/C	G/G
Leuang Nuan	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Leuang On	A/A	-9/-9	T/T	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Leuang On	A/A	-9/-9	T/T	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Leuang On	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Leuang Pin Gaew	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Leuang Sahng	A/A	A/A	G/G	ATTATGGC/ATTATGGC	C/C	C/C	G/G	C/C	A/A
Leuang Tawng	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Leuang Tawng Kam	A/A	A/A	G/G	ATTATGGC/ATTATGGC	C/C	C/C	G/G	C/C	G/G
Li Saw	G/G	A/A	G/G	-/-	C/C	A/A	G/G	G/G	G/G
Luang Pra Tahn Tia	A/A	A/A	G/G	-/-	C/C	A/A	A/A	C/C	G/G
Mea Paed	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	A/A	G/G	C/C	G/G
Nahng nuan	A/A	-9/-9	T/T	-/-	G/G	A/A	G/G	C/C	G/G
Neua Phrae	G/G	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	C/C	G/G	G/G	A/A
Niaw Dam	A/A	A/A	G/G	ATTATGGC/ATTATGGC	C/C	C/C	G/G	G/G	G/G
Niaw Leuad Raed	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	G/G	G/G
Niaw San Pah Tawng	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	G/G	G/G
Pah Leuad Kwahy	G/G	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	A/A	G/G	G/G	G/G
Pathum Thani 1	G/G	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	C/C	G/G	G/G	G/G
Pho Bai Si	G/G	C/C	A/A	C/C	C/C	C/C	T/T	G/G	G/G
Phrae Nahy Khao	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	A/A	A/A	C/C	G/G
Pin Gaew Bow	A/A	A/A	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Pla Siw Khao	A/A	G/G	G/G	ATTATGGC/ATTATGGC	C/C	A/A	G/G	C/C	A/A
Pleaug Khao	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	A/A	A/A	C/C	A/A
Pra Plerng	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	A/A	G/G	G/G
Puey ter	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	G/G	A/A	A/A	C/C	A/A
PW273	A/A	G/G	G/G	ATTATGGC/ATTATGGC	G/G	A/A	G/G	C/C	G/G
Samer Jai	A/A	A/A	T/T	ATTATGGC/ATTATGGC	C/C	A/A	G/G	C/C	G/G
Ta Pao Lom	G/G	T/T	G/G	A/A	A/A	C/C	T/T	G/G	G/G
Wi	A/A	-9/-9	G/G	ATTATGGC/ATTATGGC	C/C	C/C	G/G	C/C	G/G

Table S2 (Continued ...)

Variety/SNP marker	R08002890407	R09007245205	R09007245448	R09007245650	R09007245739	R09007246222	R09006405230	R09007246804	R09004198183
55NM S-4Neu	-9/-9	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Beu Ner Ber	A/A	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Bow Hawm	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Chahw Khao	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Daw Hawm	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Daw Hawm	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Daw Hawm26	G/G	A/A	C/C	-9/-9	C/C	T/T	T/T	G/G	A/A
Daw Hawm	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Daw Hawm	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Daw nok Gaen	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Dawk Pud	A/A	T/T	T/T	G/G	G/G	G/G	C/C	T/T	A/A
Di Si	A/A	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
E-long mah	G/G	T/T	T/T	G/G	G/G	G/G	-9/-9	T/T	A/A
E-meud	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
E-neuang	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
E-pun	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
E-tawd	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Gaew	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Gahb Sahng	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Gai Hai	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Gam	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	C/C
Gao Nam Pueng	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Ha Ruang Bow	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Hawm Bai	G/G	A/A	C/C	A/A	C/C	T/T	T/T	G/G	A/A
Hawm Dong	A/A	T/T	T/T	G/G	G/G	G/G	-9/-9	T/T	A/A
Hawm Mali	-9/-9	T/T	T/T	G/G	G/G	G/G	T/T	T/T	A/A
Hawm Nahng Nuan	A/A	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Hawm Pa mah	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Hawm Ta Kai	A/A	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Hawm Tang	G/G	A/A	C/C	A/A	C/C	T/T	T/T	G/G	A/A
Hin Gawng	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Khao Daeng	-9/-9	A/A	C/C	A/A	C/C	T/T	T/T	G/G	C/C
Khao Gaw Diaw	A/A	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Khao Hahw	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Khao Hawm	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Khao Hawm	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Khao jan	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Khao Kha Men	A/A	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Khao Luang	G/G	T/T	T/T	G/G	G/G	G/G	C/C	T/T	A/A
Khao Mali	G/G	A/A	C/C	-9/-9	C/C	T/T	-9/-9	G/G	A/A
Khao Nag	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Khao Pa Gad	A/A	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Khao Pa Ma	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Khao Sa Ong	A/A	T/T	T/T	G/G	G/G	G/G	-9/-9	T/T	A/A
Khao Sa-ard	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Khao Samer	A/A	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Khao Seht ti	A/A	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Khe Tom Gam Nan	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Lang Gany Mawn	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Leb Chahng	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Leuang	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Leuang Gra Bang	G/G	A/A	C/C	A/A	C/C	T/T	T/T	G/G	A/A
Leuang hai	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Leuang Nuan	A/A	T/T	T/T	G/G	G/G	G/G	C/C	T/T	C/C
Leuang On	A/A	T/T	T/T	G/G	G/G	G/G	-9/-9	T/T	A/A
Leuang On	A/A	T/T	T/T	G/G	G/G	G/G	C/C	T/T	A/A
Leuang On	A/A	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Leuang Pin Gaew	A/A	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Leuang Sahng	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Leuang Tawng	A/A	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Leuang Tawng Kam	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Li Saw	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Luang Pra Tahn Tia	G/G	T/T	T/T	G/G	G/G	G/G	C/C	T/T	A/A
Mea Paed	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Nahng nuan	A/A	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Neua Phrae	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Niaw Dam	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	C/C
Niaw Leuad Raed	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Niaw San Pah Tawng	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Pah Leuad Kwahy	G/G	A/A	C/C	A/A	C/C	T/T	T/T	G/G	A/A
Pathum Thani 1	G/G	A/A	C/C	A/A	C/C	T/T	C/C	T/T	C/C
Pho Bai Si	A/A	G/G	T/T	C/A	C/C	A/A	G/G	C/C	G/G
Phrae Nahy Khao	A/A	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Pin Gaew Bow	A/A	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Pla Siv Khao	G/G	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	C/C
Pleaug Khao	G/G	A/A	-9/-9	A/A	C/C	T/T	-9/-9	G/G	C/C
Pra Plerng	A/A	A/A	C/C	A/A	C/C	T/T	-9/-9	G/G	A/A
Puey ter	A/A	A/T	C/T	A/G	C/G	T/G	-9/-9	G/T	A/A
PW273	-9/-9	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A
Samer Jai	G/G	A/A	C/C	A/A	C/C	T/T	T/T	G/G	A/A
Ta Pao Lom	A/A	G/G	T/T	T/T	C/C	A/A	G/G	C/C	G/G
Wi	G/G	A/A	C/C	A/A	C/C	T/T	C/C	G/G	A/A

Table S2 (Continued ...)

Variety/SNP marker	R11021481048	R11013840467	R11014118135	R11014169508	R11028209211	R12022373643	R12018759236	R12018856177	R12023173265
55NM S-4Neu	ATT/ATT	A/A	G/G	A/A	-9/-9	A/A	G/G	A/A	T/T
Beu Ner Ber	-9/-9	G/G	G/G	A/A	A/A	G/G	T/T	A/A	T/T
Bow Hawm	ATT/ATT	A/A	A/A	C/C	T/T	A/A	T/T	A/A	T/T
Chahw Khao	ATT/ATT	G/G	G/G	A/A	T/T	G/G	G/G	A/A	T/T
Daw Hawm	-9/-9	A/A	A/G	C/A	A/A	G/G	T/T	A/A	T/T
Daw Hawm	-/-	A/A	G/G	A/A	A/A	G/G	T/T	A/A	T/T
Daw Hawm26	-/-	A/A	G/G	A/A	T/T	G/G	T/T	A/A	T/T
Daw Hawm	ATT/ATT	G/G	G/G	A/A	T/T	G/G	T/T	G/G	T/T
Daw Hawm	-/-	A/A	G/G	A/A	-9/-9	G/G	T/T	A/A	T/T
Daw nok Gaen	-/-	A/A	G/G	C/C	T/T	G/G	T/T	A/A	T/T
Dawk Pud	ATT/ATT	A/A	G/G	C/C	A/A	A/A	T/T	A/A	T/T
Di Si	ATT/ATT	A/A	G/G	C/C	A/A	A/A	T/T	A/A	A/A
E-long mah	-/-	A/A	A/A	C/C	A/A	G/G	T/T	A/A	T/T
E-meud	-/-	A/A	G/G	C/C	A/A	A/A	T/T	A/A	T/T
E-neuang	-/-	A/A	G/G	A/A	A/A	A/A	T/T	A/A	A/A
E-pun	-/-	A/A	G/G	C/C	T/T	A/A	T/T	A/A	A/A
E-tawd	-/-	A/A	G/G	C/C	A/A	G/G	T/T	A/A	T/T
Gaew	-/-	A/A	G/G	C/C	T/T	A/A	T/T	A/A	T/T
Gahb Sahng	-/-	A/A	G/G	C/C	A/A	A/A	T/T	A/A	T/T
Gai Hai	-/-	A/A	G/G	C/C	T/T	A/A	T/T	A/A	T/T
Gam	ATT/ATT	A/A	A/A	C/C	A/A	A/A	T/T	A/A	T/T
Gao Nam Pueng	-/-	A/A	G/G	C/C	A/A	G/G	T/T	A/A	T/T
Ha Ruang Bow	-/-	A/A	A/A	C/C	T/T	G/G	T/T	A/A	T/T
Hawm Bai	ATT/ATT	G/G	G/G	A/A	T/T	G/G	G/G	A/A	T/T
Hawm Dong	-/-	A/A	A/A	C/C	T/T	A/A	G/G	A/A	T/T
Hawm Mali	ATT/ATT	A/A	A/A	C/C	-9/-9	A/A	T/T	A/A	T/T
Hawm Nahng Nuan	-/-	A/A	A/A	C/C	A/A	A/A	T/T	A/A	T/T
Hawm Pa mah	-/-	G/G	A/A	C/C	T/T	A/A	T/T	A/A	T/T
Hawm Ta Kai	ATT/ATT	G/G	G/G	A/A	A/A	G/G	T/T	A/A	T/T
Hawm Tang	ATT/ATT	G/G	G/G	A/A	T/T	G/G	G/G	A/A	T/T
Hin Gawng	-/-	A/A	G/G	C/C	A/A	A/A	T/T	A/A	T/T
Khao Daeng	-/-	A/A	A/A	C/C	-9/-9	A/A	T/T	A/A	-9/-9
Khao Gaw Diaw	ATT/ATT	A/A	A/A	C/C	T/T	G/G	T/T	A/A	T/T
Khao Hahw	ATT/ATT	A/A	A/A	C/C	A/A	A/A	G/G	G/G	A/A
Khao Hawm	ATT/ATT	G/G	G/G	A/A	A/A	G/G	T/T	G/G	T/T
Khao Hawm	ATT/ATT	G/G	G/G	A/A	A/A	G/G	T/T	G/G	T/T
Khao jan	-/-	A/A	G/G	C/C	A/A	G/G	T/T	A/A	T/T
Khao Kha Men	ATT/ATT	G/G	G/G	A/A	T/T	G/G	G/G	G/G	T/T
Khao Luang	-/-	A/A	G/G	C/C	T/T	G/G	T/T	A/A	A/A
Khao Mali	ATT/ATT	G/G	G/G	A/A	T/T	G/G	G/G	A/A	T/T
Khao Nag	-/-	A/A	G/G	C/C	T/T	G/G	T/T	G/G	A/A
Khao Pa Gad	ATT/ATT	A/A	A/A	C/C	T/T	A/A	T/T	A/A	A/A
Khao Pa Ma	ATT/ATT	A/A	G/G	C/C	A/A	A/A	T/T	A/A	T/T
Khao Sa Ong	-/-	A/A	G/G	C/C	A/A	G/G	T/T	A/A	T/T
Khao Sa-ard	ATT/ATT	G/G	G/G	A/A	T/T	G/G	G/G	A/A	T/T
Khao Samer	ATT/ATT	A/A	A/A	C/C	A/A	A/A	T/T	A/A	A/A
Khao Seht ti	ATT/ATT	A/A	A/A	C/C	A/A	A/A	T/T	A/A	A/A
Khe Tom Gam Nan	-/-	A/A	G/G	C/C	T/T	A/A	T/T	A/A	A/A
Lang Gany Mawn	ATT/ATT	G/G	G/G	A/A	A/A	A/A	T/T	A/A	T/T
Leb Chahng	-/-	A/A	G/G	C/C	A/A	A/A	T/T	A/A	A/A
Leuang	-/-	A/A	G/G	C/C	T/T	G/G	T/T	A/A	T/T
Leuang Gra Bang	-/-	A/A	G/G	A/A	A/A	G/G	T/T	G/G	T/T
Leuang hai	-/-	G/G	G/G	A/A	T/T	A/A	G/G	G/G	A/A
Leuang Nuan	-/-	A/A	G/G	C/C	A/A	A/A	-9/-9	A/A	A/A
Leuang On	-/-	A/A	G/G	C/C	T/T	A/A	T/T	A/A	T/T
Leuang On	-/-	A/A	G/G	C/C	T/T	A/A	T/T	A/A	T/T
Leuang On	-/-	A/A	G/G	C/C	A/A	A/A	T/T	A/A	T/T
Leuang Pin Gaew	ATT/ATT	A/A	A/A	C/C	T/T	A/A	T/T	A/A	T/T
Leuang Sahng	ATT/ATT	A/A	G/G	A/A	A/A	G/G	T/T	G/G	T/T
Leuang Tawng	-/-	G/G	G/G	A/A	A/A	A/A	G/G	A/A	T/T
Leuang Tawng Kam	-/-	A/A	G/G	C/C	A/A	G/G	T/T	A/A	T/T
Li Saw	ATT/ATT	G/G	G/G	A/A	A/A	G/G	T/T	A/A	T/T
Luang Pra Tahn Tia	ATT/ATT	A/A	A/A	C/C	A/A	A/A	T/T	A/A	T/T
Mea Paed	ATT/ATT	A/A	G/G	C/C	A/A	G/G	T/T	A/A	A/A
Nahng nuan	-/-	A/A	A/A	C/C	A/A	A/A	T/T	A/A	T/T
Neua Phrae	-9/-9	G/G	G/G	A/A	A/A	G/G	G/G	A/A	T/T
Niaw Dam	ATT/ATT	G/G	G/G	A/A	T/T	A/A	T/T	A/A	T/T
Niaw Leuad Raed	-/-	A/A	G/G	C/C	T/T	A/A	T/T	A/A	T/T
Niaw San Pah Tawng	-/-	A/A	G/G	A/A	A/A	G/G	T/T	G/G	T/T
Pah Leuad Kwahy	-/-	G/G	G/G	A/A	A/A	G/G	T/T	A/A	T/T
Pathum Thani 1	-/-	A/A	A/A	C/C	A/A	A/A	T/T	G/G	T/T
Pho Bai Si	A/A	A/A	C/C	A/A	C/C	T/T	G/G	A/A	A/A
Phrae Nahy Khao	ATT/ATT	G/G	G/G	A/A	A/A	A/A	G/G	G/G	A/A
Pin Gaew Bow	ATT/ATT	A/A	G/G	A/A	A/A	A/A	T/T	A/A	A/A
Pla Siw Khao	-/-	A/A	A/A	C/C	A/A	G/G	T/T	A/A	T/T
Pleaug Khao	-/-	A/A	A/A	C/C	A/A	G/G	G/G	A/A	A/A
Pra Plerng	-/-	A/A	A/A	C/C	A/A	G/G	G/G	G/G	T/T
Puey ter	-9/-9	A/A	A/A	C/C	A/A	A/A	T/T	A/A	T/T
PW273	ATT/ATT	A/A	G/G	A/A	-9/-9	A/A	T/T	G/G	T/T
Samer Jai	-/-	A/A	A/A	C/C	A/A	A/A	T/T	G/G	T/T
Ta Pao Lom	G/G	A/A	C/C	A/A	C/C	T/T	G/G	A/A	A/A
Wi	ATT/ATT	G/G	G/G	A/A	A/A	A/A	T/T	A/A	T/T