Research article

Variation in Grain Morphology of Upland Rice Varieties from Luang prabang Province Lao PDR

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Abstract Luang prabang province is recognized as a major area of the diversity of *Oryza sativa* L. in Lao PDR. Grain morphological characteristics can be used as the primary information of genetic variation among different rice varieties in the local germplasm which can be a source of value adding traits for rice breeding programs. The purpose of this study was evaluated variation in grain morphological characteristics of upland rice varieties from Luang prabang province, Lao PDR. The samples were collected from three districts, Ponxay (PX), Pak Ou (PO) and Xieng Ngeun (XNg), two villages each. Grain morphological characteristics were measured including grain size (length, width, and thickness), weight, shape, and endosperm type and pericarp color. The total of 60 samples were collected which was separated into 26, 10, and 24 samples from PX, PO, and XNg, respectively and among these samples 42 and 18 samples were glutinous and non-glutinous endosperm types, respectively. The 51 samples were found in non-pigmented, 4 in red and 5 in black pericarp colors. There was variation of grain size among 60 samples. Grain length, width and thickness were ranging from 8.61-11.63, 2.67-4.27 and 1.97-2.47 mm, respectively. Grain shape was determined by using the ratio of grain length/width and most samples (58 varieties) were distinguished as large grain type and the rest in slender type. One hundred grain weight was also varied from 2.05-4.04 g among brown rice of 60 samples. The grain weight was varied with grain length, width and thickness in multiple regression of $y = 0.39$ (grain length) + 0.53 (grain width) + 1.42 (grain thickness) – 5.52 at $R^2 = 0.89$ ($p < 0.05$). This study demonstrated the variation in grain morphological characteristics of upland rice varieties from Luang prabang province, Lao PDR. The variation of nutritional quality was subjected to evaluate in the further investigation which can be used as the basic information for the selection traits of rice varieties in the further breeding program.

Keywords Luang prabang, rice varieties, rice grain morphological characteristics, color, weight, village

INTRODUCTION

Grain morphological characteristics especially size and shape is an important component of grain yield and quality which have been used as the criterion of selection since cereals were first domesticated (Wang et al., 2012). Preferences for grain size and shape vary from one group of consumers to another. Some ethnic groups prefer short bold grains, some prefer medium-long grains, and other highly prize long slender grains. In general, long grains are preferred in the Indian subcontinent, but medium to medium-long rice are preferred in Southeast Asia (IRRI, 2002).

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Globally, improving quantity and quality of rice grain have been approached to solve several problems among the world population such as decreasing the number of hidden hunger and malnutrition (Burchi et al., 2011). Breeding for high yielding and nutritional quality has been suggested as strategy to solve the problems (Marie and Howarth, 1997), especially in Laos where malnutrition problems are wide spread among the population due to consumption of low nutritional value rice (WHO, 2011). On the other hand, rice is an important source of energy, iron, calcium, vitamins, and protein in the diet of the Asian population, including Laos (IRRI, 1993). However, a wide variation of grain morphological characteristics will be required as source of genetic materials in breeding for some specific traits as it would be effect on consumer's acceptance at the end of processes.

Luang prabang is one of the provinces in the northern of Lao PDR and it has been reported to be rich in genetic diversity among rice germplasms. A total of 13,192 samples of traditional varieties were collected in Lao PDR since 1995 to 2000, it was found the largest germplasm of 5,915 (44.8%) varieties in the northern region and Luang prabang had 1,243 samples (9.4% of the total) and 85.5% of the collected samples were glutinous rice (Appa Rao et al., 2002). Therefore, Luang prabang has been recognized as rice diversity areas in Lao PDR and it is approximately 25% of the total upland rice production area of the country, where rice is cultivated on sloping land using slash-and-burn methods without tillage and input fertilizers (World Bank, 1995). However, there has not been reported yet in detail on variation of some useful traits among this germplasm and grain morphology are the characters that easy and rapid to determine.

Previous studies reported that seed of local rice varieties maintained by farmers are genetically diverse (Dennis, 1987). Different varieties can be given similar names and different names can be applied to the same varieties (Harlan, 1992). Diversity analyses may be based on morphological characteristics such as shape, size and pigmentation of plant parts that local farmers use to distinguish different rice varieties (Morishima et al., 1980). Molecular techniques such as AFLP, ISSR and SSR (Saini et al., 2004) allow variation to be evaluated between individual plants. Grain morphological characteristics can be used as the primary information of genetic variation among different rice varieties in the local germplasm.

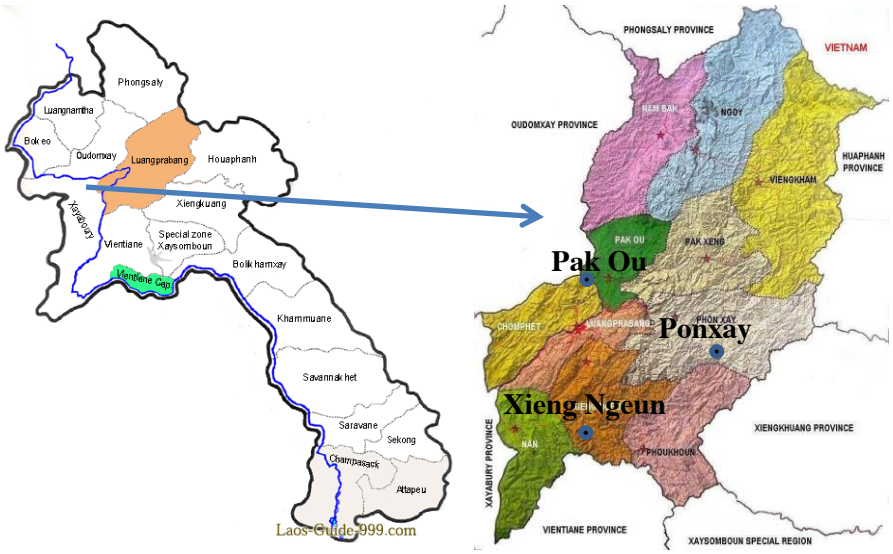

Fig. 1 Map of Luang prabang province, Lao PDR and the detail location of 3 districts (Ponxay, Pak Ou and Xieng Ngeun), where the upland rice samples were collected

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OBJECTIVE

This study was attempted to identify grain morphological characteristics of upland rice varieties collected from different locations at Luang prabang province, Lao PDR.

METHODOLOGY

Rice samples were collected among 3 districts, Ponxay (PX), Pak Ou (PO) and Xieng Ngeun (XNg) with 2 villages each from Luang prabang Province, Lao PDR (Fig. 1). The totals of 60 rice samples were collected from farmers. Grain morphological characteristics were determined among each sample of the total collection. Seed size (grain length, width, and thickness) of the unhusked seed was measured by digital Vernier caliper (50 seeds for each sample). The unhusked seeds were dehusked manually by hand to separate between the husk and brown rice. The 100 grains weight of unhusked and brown rice grains was weighed in 3 independent replications. The color of hull and pericarp was also recorded. The analysis of variance was used to determine the significant difference of each morphological characteristic among rice varieties at $p<0.05$ by statistical analysis software STATISTIX 8.0. The Least Significant Difference was used to indicate the difference of grain size, weight and shape among varieties.

RESULTS AND DISCUSSION

The total of 60 upland rice samples (42 glutinous and 18 non-glutinous endosperm types) were collected from three districts with 2 representative villages each of Luang prabang province, Lao PDR. 26 samples from PX (14 in Chomchieng (CC) and 12 in Houameuang (HM)), 10 samples from PO (6 in Hoi-Oth (HO) and 4 in Hoi-Loh (HL)) and 24 samples from XNg (10 in Phasanine (PSN) and 14 in Phouthat (PT)). Luang Prabang has been designated as one of the center diversity of *Oryza sativa* L. in Laos (Appa Rao et al., 2002). Even though many characteristics have not been evaluated the variation yet, but genetic diversity among the germplasm has been declared in this area. The variation of endosperm type is depending on the usual consumption and traditional preference among consumers in each area. It has been reported that Hmong ethnic group preferred to consume non-glutinous rice rather than glutinous rice, while Khamu ethnic group preferred glutinous rice (Sengxua, 2006; Roder et al., 1996).

Grain Morphological Characteristics

51 samples found in off white pericarp color (non-pigmented color) (33 in glutinous and 18 in non-glutinous), 4 in red and 5 in black color (glutinous). This suggests that the highland rice germplasm is mostly in white pericarp color which may not depend on the satisfying on the demand market, but their consumption preference. However, special quality rice, e.g. varieties with pigmented pericarp with black and red color has been found and recognized as high antioxidative properties which can protect against oxidative damages in a range of diseases such as cardiovascular and cancer diseases (Cicero and Derosa, 2005). Unlike grain shape and size, these properties can be varied according to the interaction between rice varieties x growing condition which should carefully pay attention when dealing with these properties in the future (Nkori Kibanda and Luzi-Kihupi, 2007).

Grain weight and size of brown rice was varied among different rice samples collected ($p < 0.05$) (Table 1). 100-grain weight was ranged from 2.05-4.04 g. The grain weight was varied with the heaviest and lightest grains weight found in varieties *Mai-hoke* (4.04 g) from HM and *Kao siew* (2.05 g) from HL, respectively. The grain length ranged from 8.61-11.63 mm with the average of 10.00 mm. The shortest and longest grains were found in varieties *Chao khao 2* (8.61 mm) from PSN and *Leum*

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poua (11.63 mm) from HM, respectively. The grain width ranged from 2.67-4.27 mm with the average of 3.51 mm. The narrowest and widest grains found in varieties *Kao siew* (2.67 mm) from HL and *Luang leuang* (4.27 mm) from HM, respectively. The thickness of individual unhusked grain ranged from 1.97-2.47 mm. The thinnest and thickest grains found in *Kao siew* (1.97 mm) and *Niew mad-deng* (2.47 mm) from PSN, respectively. Grain size and shape are associated with milling quality, grain weight and proportion of the main growth axes of the grain (Gegas et al., 2010). The grain size and shape can be effectively used to improve yield and grain quality (Wang et al., 2012), and are among the first quality characteristics considered in developing new commercial varieties (Webb, 1980). Therefore, breeding for specific grain weight together with some other useful traits should carefully consider of grain size as it was found in this study. Thus, a diverse range of grain size and shape among these germplasms will be useful in breeding program as source of genetic materials when dealing with specific shape for consumer's demand.

Table 1 Grain morphological characteristics of the collected 60 rice samples

Collection place	Variety	Type of rice	Grain Morphological Characteristics					
			Length (mm)	Width (mm)	Thickness (mm)	L/W ratio	100-grain weight	pericarp color
Chomchieng village	Parker	G	11.23	3.86	2.36	2.92	3.77	white
	Hom-ma-li	NG	11.20	2.99	2.11	3.75	2.82	white
	Bor-ta	G	11.09	3.73	2.35	2.97	3.32	white
	Kam leuang-yao	G	10.43	3.59	2.18	2.91	2.76	black
	Kao peing	G	10.15	3.59	2.29	2.83	3.25	white
	Chao dam	NG	9.73	3.19	2.19	3.06	2.82	white
	Kam mad-dam	G	10.07	3.90	2.22	2.58	2.79	black
	Kam leuang-dam	G	9.14	3.73	2.18	2.46	2.42	black
	Kao din	G	9.08	3.30	2.12	2.75	2.48	white
	Niew mad-pom	G	9.90	3.82	2.37	2.60	3.36	white
	Chao khoon	NG	9.62	3.32	2.12	2.90	2.77	white
	Chao deng	NG	9.46	3.18	2.16	2.98	2.36	white
	Kao wai	G	11.02	3.34	2.28	3.32	3.07	white
	Chao leuang	NG	10.45	3.41	2.27	3.07	3.27	white
Houameuang village	Kao paie	G	9.50	3.24	2.20	2.94	2.33	red
	Kam khao-dam	G	9.89	3.79	2.32	2.61	2.88	black
	Kao ngeun	G	10.27	3.72	2.32	2.77	3.33	white
	Ki-kung	G	9.82	3.87	2.38	2.54	3.35	white
	Pa-ya	G	10.48	4.02	2.39	2.61	3.41	white
	Leum-poua	G	11.63	3.90	2.33	2.99	3.78	white
	Kao Chuk	G	9.45	4.08	2.37	2.32	3.40	red
	Mai-hoke	G	11.52	3.81	2.44	3.03	4.04	white
	Kao hoke	G	8.67	3.68	2.24	2.36	2.70	white
	Chao leuang 2	NG	10.12	3.32	2.09	3.06	2.77	white
	Kai-noi	G	10.49	3.23	2.17	3.26	2.74	white
	Luang leuang	G	9.28	4.27	2.42	2.18	3.55	white
Hoi-Oth village	Kam dor	G	9.40	3.68	2.18	2.56	2.48	black
	Chao khao	NG	9.56	3.26	2.09	2.94	2.68	white
	Niew valee	G	10.95	3.57	2.25	3.08	3.24	white
	Niew leuang	G	10.10	3.22	2.15	3.15	2.76	white
	Chao peak-peing	NG	9.17	3.43	2.20	2.68	2.75	white
	Kao ying	G	10.17	3.21	2.15	3.17	2.84	white

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Hoi-Loh village	Chao valee	NG	10.87	3.02	2.12	3.61	2.85	white
	Chao mad-pom	NG	9.22	3.50	2.15	2.64	2.53	white
	Mak-kheua	G	8.76	4.14	2.34	2.12	2.99	white
	Kao Siew	G	10.33	2.67	1.97	3.88	2.05	white
Phasanine village	Leuak-yai	NG	9.50	3.07	2.06	3.10	2.61	white
	Chao khao 2	NG	8.61	3.09	2.14	2.79	2.47	white
	Kao yuak	G	11.59	3.71	2.26	3.14	3.63	white
	Sia-cha	NG	9.26	3.11	2.09	2.98	2.43	white
	Luang deng	G	9.21	4.17	2.42	2.22	3.56	white
	Chao dam 2	NG	9.72	3.16	2.21	3.08	2.80	white
	Kao peing 2	G	10.14	3.51	2.31	2.90	3.12	white
	Niew mad-deng	G	9.56	4.13	2.47	2.32	3.36	red
	Chao-leuang 3	NG	10.03	3.26	2.12	3.09	2.63	white
	Kao din 2	G	9.56	3.18	2.08	3.03	2.51	white
Phouthat village	Kao tam	G	8.92	3.51	2.39	2.55	2.53	white
	Ka-yoke	G	11.33	3.61	2.28	3.16	3.55	white
	Kao Kang	G	10.86	2.97	2.16	3.68	2.82	white
	Niew leuang 2	G	9.36	3.42	2.30	2.76	2.87	white
	Nam-manh	G	9.36	3.99	2.40	2.35	3.23	white
	Niew peak-peing	G	9.27	3.68	2.35	2.53	2.86	white
	Poua-mia	G	10.07	3.50	2.27	2.89	2.75	white
	Kao peing 3	G	10.95	3.66	2.37	3.01	3.31	white
	Ma-ma	G	10.24	3.62	2.24	2.84	2.92	white
	Niew mad-deng 2	G	9.39	3.93	2.40	2.41	3.18	red
	Chao khao 3	NG	9.70	3.03	2.12	3.21	2.60	white
	Leuak-yai 2	NG	10.20	3.13	2.20	3.27	2.75	white
	Leuak-noi	NG	9.61	3.06	2.12	3.15	2.61	white
	Kao yai	G	11.32	3.73	2.44	3.04	3.89	white
n			60	60	60	60	60	
min			8.61	2.67	1.97	2.12	2.05	
max			11.63	4.27	2.47	3.88	4.04	
mean			10.00	3.51	2.24	2.88	2.96	
SD			0.78	0.36	0.12	0.38	0.43	
CV (%)			1.47	1.59	2.05	1.68	1.36	
F-test			**	**	**	**	**	
LSD (0.05)			0.24	0.09	0.07	0.08	0.07	

*** Significant difference at p< 0.01; CV= coefficient of variation; SD= standard deviation; n= number of sample; min= minimum; max= maximum; LSD= least significant difference at p< 0.05; G: Glutinous; NG: Non-glutinous The value of grain size in each sample is averaged from 50 grains.*

The ratio of grain length/width was used to separate grain shape of unhusked rice. Most samples (58 varieties) were distinguished as large grain type and the others 2 samples are slender type (Fig. 2). Grain weight was varied with grain length, width and thickness in multiple regression of y = 0.39 (grain length) + 0.53(grain width) + 1.42(grain thickness) – 5.52 at $R^2 = 0.89$ ($p < 0.05$).

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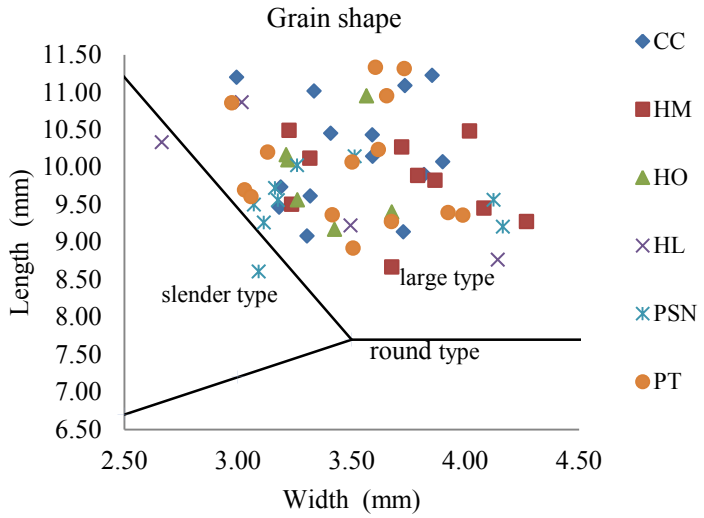

Fig. 2 The grain shapes of unhusked grain among rice samples

CONCLUSION

A wide variation of grain morphological characteristics has been found among the local upland rice as it was expected among the collected samples.

Most of rice samples are in a large grain shape with only few samples are slender type. Grain weight is an important characteristic in commercial networks as it is used to determine the production and price of rice. In this germplasm, Grain weight was varied with grain length, width and thickness in multiple regression of y = 0.39 (grain length) + 0.53(grain width) + 1.42(grain thickness) – 5.52 at R^2 = 0.89 ($p < 0.05$). The results of this study can be used as the basic database of rice germplasm in Luang prabang province for the selection of rice varieties in further breeding program. However, other useful traits of nutritional qualities such as iron, zinc, protein, silicon and antioxidant properties should be further evaluated.

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