Research article

Validated Rice Cultivars for Rice-Based Systems of the Northern Mountainous Region, Lao PDR

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Abstracts This study aimed to identify and evaluate appropriate introduced and improved sloping upland rice cultivars for the northern region of Lao PDR (Bokeo, Houphanh, Luangnamtha, Luangprabang, Oudomxai, Phongsaly, Sayabuly, and Xiengkhuang). The study was designed to detect genotype by environment for seven cultivars: 1) Makhinsoung, 2) Nok, 3) Non, 4) Laboun, 5) IR55423-1, 6) B6144F-MR-6 and 7) IR60080-46A in the farmer's field with farmer practices and farmer's preferences analysis. The results showed that both introduced and improved rice varieties consistently produced higher grain yield compared to local varieties, from 157 to 381 kg/ha over years that the experiments were conducted. Local varieties yielded an average of 1700 kg/ha. Most of the varieties were suitable for Oudomxai, Sayabuly and Xiengkhuang provinces. Some varieties were specifically appropriate for some provinces: Non (Bokeo), IR60080-46A (Houaphanh and Luangnamtha). Yield data of all tested varieties were generally significantly different from that of local variety. However, grain yield differences of entries in Luangprabang and Phongsaly were not significant, but almost all the entries cultivars produced more grain than local checks.

Keywords plant characteristics, rice cultivar validation, northern mountainous and upland cultivation

INTRODUCTION

Rice is the primary staple crop of Lao PDR. It accounts for 70% of the diet and supplies about 70% of caloric requirement. Among Lao people, rice self-sufficiency is equated to food self-sufficiency (Linquist et al., 2007). Laos achieved rice self-sufficiency in 1999; upland farmers and households are still rice-deficient.

The uplands of Lao PDR are located in northern part of the country and along the Laos-Vietnamese border in the central and southern regions. The northern uplands form the largest upland environment in Lao PDR, comprising seven, out of eighteen provinces that make up the whole of Laos. It is predominantly mountainous, but there are a number of minor plains and numerous flat intermountain basins and narrow river valleys where water is available year-round, allowing for full or partial irrigated agriculture. Upland farmers grow rice in the intermountain basin, and river valleys as transplanted wetland or lowland paddy rice, and on the sloping uplands as direct-seeded

upland rice. The uplands also provide a range of agro-ecological environments that enable farmers to grow cash crops, paper mulberry, cassava, and beans, among other crops.

Surveys of upland households show that livelihoods are overwhelmingly agricultural in nature. Farmers with more lowland had better food security than farmers who raised their crops purely on upland sloping environments. Seventy three percent of households reported at least 1 year of rice deficiency in 10 years (1995-2005). In contrast, only 17% of households with lowland reported at least one year of rice deficiency during the same period.

The major constraints to improve rice production in the uplands are low productivity of rice varieties, lack of high quality seeds and livestock diseases, inadequate extension services, limited access to public services and advanced technologies, poorly developed transport, irrigation and marketing infrastructures (Roder, 2001).

This paper aims to describe the process and results of a long-term effort to evaluate and identify appropriate rice germplasm for the uplands of Lao PDR through multi-environment yield trials.

METHODOLOGY

Multi-environment yield trials were conducted on farmers' fields, with farmer participation, in eight provinces of the northern region of Lao PDR: Sayabuly, LuangPrabang, Oudomxai, Luang-Namtha, Bokeo, Phongsaly, Houaphanh, and Xiengkhuang. The field research sites were selected to represent the northern region of Lao PDR. Oudomxai and Sayabuly provinces had more farmer participants from 2005 to 2009. Elevation of field sites ranged from 300m to 1300m. Fields were selected to be representative of upland environments.

Seven lines and cultivars were used in the trials. Laboun, Non, Nok, and Makhinsoung are traditional cultivars which have been identified from a series of screening trials to perform well under a range of upland conditions. These cultivars have been purified so that each variety is distinctive, recognizable and produce uniform crop stands in the field. IR55423-1, B6144F-MR-6, IR60080-46A are improved, stable, non-glutinous rice lines which perform well in upland environments. Seeds were direct-seeded on dry soil. Crops were managed according to local practice. Neither fertilizer nor other agricultural chemicals were used on the crop. At the time of harvest, crop cuts were taken to determine grain production of the lines and cultivars. Data from 2003 to 2009 were included in the analysis. Data were tabulated and graphically evaluated.

Preference analyses by farmers were conducted prior to harvest. Farmers were asked to identify the reasons why they liked or disliked particular varieties. These data were tabulated and graphically evaluated.

RESULTS

Table 1 shows the mean grain yield of seven rice cultivars in eight northern Lao PDR provinces. Under farmer management practices, grain yields of test cultivars were significantly better than those of local check varieties. Yield advantage of rice lines and selected and purified glutinous landrace varieties ranged from 157-381 kg/ha (9-22%). Improved non-glutinous varieties (IR 55423-1, B 6144F-MR-6, IR 60080-46A) produced 167-334 kg/ha (10-20%) more grain than local checks. Selected and purified traditional cultivars (Laboun, Non, Nok, and Makhinsoung) produced 157-381 kg/ha (9-22%) more grain than checks.

Sites where the trials were conducted were significantly different in mean rice production across the years examined (Table 2). Bokeo had the highest mean annual rice production (2,309 kg /ha) among eight provinces, while Phongsaly and Xiengkuang had the lowest (1,615 kg/ha).

Table 2 also shows that mean rice production, across sites, was more than 1,800 kg/ha from 2003 to 2007. Production declined in 2008 and 2009. The trend of production is shown in Figure 1. IR60080-46A exhibited the best yields in 2003 and 2004, during the "good" years for rice production. However, B6144F-MR-6 did best in 2006 and 2008. Laboun performed best in 2005, 2007 and 2009. These observations may indicate that these lines and cultivars are highly adaptable to both "good" and "bad" rice growing years.

Table 1 Mean grain yield of seven test lines and cultivars and their yield advantage over local varieties

Varieties	Grain yield (kg/ha)		Grain yield advantage (kg/ha)	Grain yield advantage (%)
Laboun	2080	a	381	122
Non	2038	ab	339	120
IR60080-46A	2034	ab	334	120
B6144F-MR-6	2017	ab	318	119
Nok	1887	abc	188	111
IR55423-1	1867	bc	167	110
Makhinsoung	1857	bc	157	109
Local	1700	c	0	100
SE(N= 9)	76			
5%LSD 780DF	210			
PR>F	0.0001			

Table 2 Mean annual rice grain yield in eight northern Lao PDR provinces

Provinces	Annual grain yield (kg/ha)							Mean (kg)
	2003	2004	2005	2006	2007	2008	2009	
Luangprabang	1908	2037	1995	2036	1663	1407	1610	1808
Oudomxai	2239	1861	1604	1336	2881	1057	1771	1821
Houphanh	-	-	1941	2184	1615	-	-	1913
Luangnamtha	1311	1830	2035	1341	1957	-	-	1695
Phongsaly	1783	1351	1860	-	-	-	1467	1615
Sayabuly	1843	2784	2720	2712	-	-	1313	2275
XiengKuang	1886	1497	1383	2128	-	-	1187	1616
Bokeo	2627	2810	1523	1693	2893	-	-	2309
Mean (kg)	1942	2024	1883	1919	2202	1232	1469	1882
SE(N=99)	187							
5%LSD 780DF	518							
PR>F	0.000							

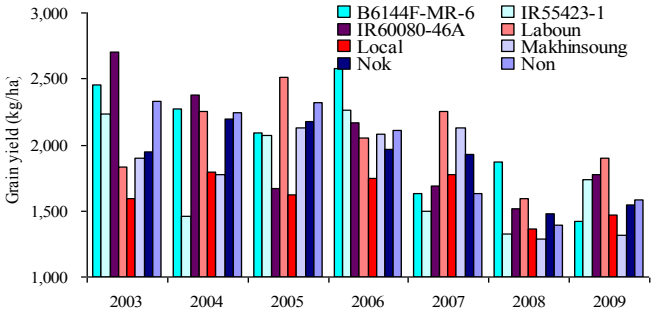

Fig. 1 Grain yield of seven rice lines and cultivars over seven years, averaged across sites

Rice lines and cultivars performed well in Oudomxai, Sayabuly and Xiengkhuang provinces (Table 3). Some varieties performed well in specific provinces, such as Non in Bokeo province, and IR60080-46A in Houphanh and Luangnamtha. However, none of varieties stood out in terms of grain production in Luangprabang and Phongsaly provinces. Almost all lines and cultivars in the test set, except Makhinsoung, and the checks produced more than 2,000 kg/ha in Sayabuly province sites.

Fig. 2 gives a human dimension to the grain yield data. The graphic summarizes farmer opinions and comments on traits that they liked and disliked about the lines and cultivars in the test set. Large panicles, big-sized grain and strong culms were the most commonly referred to positive characteristics. Farmers did not like cultivar that produced few tillers, short and non-uniform panicles.

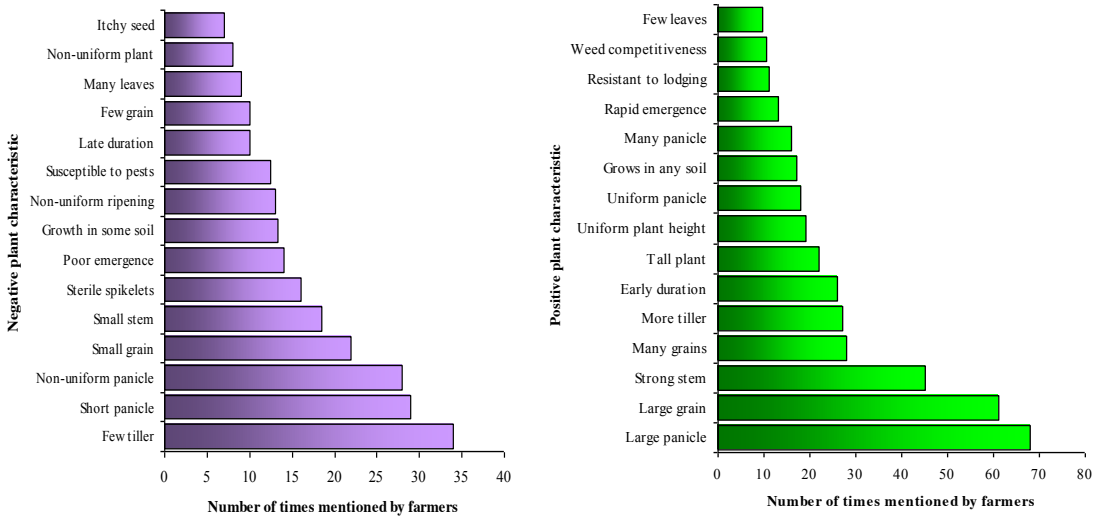

Fig. 2 Positive and negative plant characteristics most mentioned by farmers

Table 3 Grain yield of rice lines and cultivars in eight northern Lao PDR provinces

Varieties	Bokeo	Houa phanh	Luang namtha	Luang prabang	Oudom xai	Phongsaly	Sayabuly	Xieng khuang
B6144F-MR-6	1710	1659	1887	1814	2511	1458	3748	2233
IR55423-1	1706	1974	1789	1753	1508	1091	3595	1344
IR60080-46A	1720	3577	2276	1828	2913	1628	4496	2133
Local	1704	1934	1686	1668	1456	1627	2251	1524
Laboun	1688	1954	1807	2040	2680	1470	3160	2294
Makhinsoung	1789	2148	1817	1697	2108	2052	1761	2366
Nok	1380	1951	1638	1881	2074	1086	2108	2700
Non	2478	1953	1683	1993	2040	2028	2072	1928
SE(N=12)	205							
5%LSD 724DF	570							
PR>F	0.0000							

Based on the preferences of farmers, six (Nok, Makhinsoung, Laboun, Non, IR55423-1 and B6144F-MR-6) were propagated. Production of seeds for distribution to farmers was ramped up from 2005 to 2009 (Table 4). Makhinsoung and Nok distribution to farmers was more than 2 and 3 tons, respectively, in 2009. B6144F-MR-6 distribution peaked at 2 tons in 2007.

Table 4 Amount of rice seed distributed (kg) from 2005 to 2009

Varieties	Seeds distribution in each year (kg)				
	2005	2006	2007	2008	2009
Nok	30	230	220	2585	3317
Makhinsoung	20	100	200	1079	2207
Laboun	20	250	250	340	1145
Non	20	30	-	70	527
IR55423-1	5	20	30	50	163
B6144F-MR-6	10	800	2000	25	165
Total	105	1430	2700	4149	7524

The number of farmers planting the lines and cultivars, and the amount of seeds they used are summarized in Table 5. There was a steady increase in number of farmers planting the lines and cultivars and the amount of seeds that they used, except for IR55423-1. By 2008, fifty farmers were

using Non and Nok, but larger amounts of seeds were being used by farmers using Nok, perhaps implying that larger areas of land were being sown to his cultivar. The number of farmers trying out B6144F-MR-6 increased to 70 by 2008 but the amount of seed used was static from 2008 to 2009 at about 900 kg. This probably means that more farmers were trying out the line, but steady uptake was not yet occurring for this rice line. It is worth noting that these data are limited to the farmers and farm households that could be tracked by the researchers and does not include unreported seed exchanges and sales.

Table 5 Number of farmers planting selected rice lines and cultivars and amount of seed used from 2006 to 2008

Variety	2006		2007		2008	
	Farmers	Amount of seed (kg)	Farmers	Amount of seed (kg)	Farmers	Amount of seed (kg)
Nok	5	2.5	8	220	50	2585
Makhinsoung	5	2.5	7	200	27	1079
Laboun	5	2.5	10	100	20	800
Non	5	2.5	4	100	50	450
IR55423-1	5	2.5	2	30	3	50
B6144F-MR-6	5	2.5	50	900	70	850

DISCUSSION

Results showed that both introduced lines, and selected / purified landraces performed better, under the same environmental conditions, as local varieties (Asai et al., 2009). However, other reported that only the improved rice germplasm produced higher yields in both low and high fertility conditions over a number of locations (Saito et al., 2007). The average grain yield of the test lines and cultivars was higher than that of the local varieties in all sites. This supports the findings (Atlin et al., 2006). Higher productivity may be due to high sink size of improved lines and selected/purified landraces, manifested by their larger panicle number per unit area. Panicle number has been reported to be an essential trait for high grain yield in low as well as high soil fertile uplands in Asia and West Africa (Saito and Futakuchi, 2009). Poor adaptation of tropical japonica rice genotypes to low soil fertility conditions may be the result of reduced sink size and grain-filling percentage.

Our results suggest that improved indica rice and selected/purified traditional rice cultivars can improve productivity without addition of fertilizer, even in low soil fertility conditions (short fallow cycle). This finding is significant and important for resource-poor farmers, who have faced difficulty in maintaining rice productivity in short-fallow slash-and-burn systems in northern Laos. Other reasons for those select/purified traditional rice cultivars were preferred and adopted in large areas by Laos farmers, because they were glutinous rice and big-sized grain. And most of Laos's farmers preferred glutinous cultivars than non-glutinous cultivars.

The use of these genotypes should only be seen as a component for improving upland rice-based cropping systems since continuous rice cropping with such high-yielding genotypes can lead to a greater nutrient withdrawal from the soils as well as a more rapid decline of soil organic carbon in upland conditions (Saito et al., 2006b; Asai et al., 2007). Therefore, integrated soil fertility management practices need to be developed for effective use of sustainable rice production.

CONCLUSIONS

This paper showed that indica and tropical japonica rice genotypes differed in yield response to soil fertility conditions under rainfed uplands in northern Laos. Grain yield of rice genotypes were not stable across low and high soil fertility conditions. Grain yield of introduced improved rice lines, and selected/purified cultivated varieties were generally significantly better than local varieties.

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