

Response of traditional and improved upland rice cultivars to N and P fertilizer in northern Laos

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Abstract

Upland rice is typically grown under slash-and-burn systems in the mountainous regions of northern Laos by resource-poor farmers for subsistence. Upland rice cultivars are all traditional and no fertilizer inputs are used. In these systems, grain yields average only 1.7 t/ha. A multi-site experiment was conducted in Luang Prabang province to examine cultivar and fertilizer effects on grain yield. Three traditional and three improved cultivars were grown under four fertilizer treatments: no added fertilizer, nitrogen only (N; 90 kg N/ha), phosphate only (P; 50 kg P/ha), and N and P (NP) at three locations. No severe water stress developed at any location.

The two improved cultivars, IR55423-01 and B6144-MR-6-0-0 out-yielded traditional cultivars in all locations and fertilizer treatments. They had higher total dry matter and harvest index, lower plant height and more panicles than traditional cultivars. N fertilizer application increased grain yields of the two improved cultivars from 3.1 to 4.0 t/ha while increasing those of traditional cultivars from 1.6 to 1.9 t/ha. Applying only P gave no effect on grain yield, and applying P with N increased grain yield only by 0.5 t/ha over N application alone on average over all cultivars at all locations. However, there was cultivar and location difference in the yield response to P applied with N. Further studies are required on the genotype-by-environment interaction in the effect of P applied with N under upland conditions. These results indicate that upland rice cultivars with high HI, which have been selected under favorable conditions, can perform well under low fertility conditions but also respond well to applied N fertilizer.

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1. Introduction

Upland rice is typically grown without fertilization in slash-and-burn systems in the mountainous region of northern Laos by resource-poor farmers for subsistence. It yields an average of 1.7 t/ha versus 3.6 t/ha for wet season lowland rice, and accounts for about half of the total rice area in this region (National Statistical Center, 2004). Because of its low yield, upland rice is generally considered to be unsuitable for the intensive management practices aimed at high yields. However, the low yield of upland rice is largely a consequence of its production being limited to infertile or

drought-prone uplands, and to low harvest index (HI) of traditional cultivars (George et al., 2001). Traditional cultivars are generally tall, have few tillers, and produce low but stable yields under unfavorable environments. They tend to lodge under favorable conditions and are thus not suited to high-input management. In northern Laos, no improved upland rice cultivars have yet been released. The Lao-IRRI project has screened over 3000 traditional accessions to identify those that are more productive and perform better under slash-and-burn systems with shortened fallow. Currently, through participatory varietal selection (PVS) trials conducted over 4 years, two traditional cultivars (Nok and Mak hin sung) have been identified which yield 0.3–0.5 t/ha more, on average, than local check cultivars (an 18–27% increase in yield) (Songyikhangsuthor et al., 2002;

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Linguist et al., 2004). It is likely that little further improvement in yields can be achieved by selecting only among local traditional cultivars, and different approaches are required for further improving yields of upland rice. Improved, input-responsive upland rice cultivars have been developed in Southeast Asia which can achieve yields of more than 5 t/ha under relatively nutrient-rich and drought-free growing conditions (George et al., 2002). Improved upland cultivars have high HI relative to traditional cultivars (Atlin and Lafitte, 2002). But it is not known whether the cultivars are suitable for the uplands of northern Laos where traditional cultivars are considered to be adapted.

Nitrogen (N) and phosphate (P) deficiencies are the most important nutrient disorders in the upland conditions of northern Laos (Roder et al., 1995; George et al., 2001; Roder, 2001). Using traditional cultivars, various field fertilizer experiments have been conducted during 1991–2003 (Roder, 2001; Lao-IRRI, 1991–2003). These trials indicated that there was low response of traditional cultivars to N fertilizer application. Applying only P gave no effect on grain yields in spite of increased P uptake (George et al., 2001; Lao-IRRI annual report, 2003). These may indicate that the traditional cultivars are less responsive to N and P fertilizer application. However, little information is available on upland rice cultivar differences in response to N and P fertilization in Asia.

The objective of this study is to examine the effects of cultivar and N and P fertilization on grain yield in northern Laos, and to determine if improved, introduced upland rice cultivars differ from traditional cultivars in response to N and P fertilization. The experiment was conducted at three locations differing soil fertility in Luang Prabang province in 2004.

2. Materials and methods

Rainfed upland rice experiments were conducted at the Northern Agriculture and Forestry Research Center (Houay khot village in Xiengngun district), and in two farmers' fields (Somsanuck village in Pak Ou district and Houay hia village in Xiengngun district) in Luang Prabang province in northern Laos. The experimental locations were typical of upland rice farming areas in northern Laos and general

information for the three locations is presented in Table 1. Two of the three locations previously had a 3-year fallow, while at Somsanuck, upland rice was grown in the previous wet season. Each experiment was conducted on a level area to avoid soil erosion. The area in Somsanuck was terraced with bunds but rice was grown aerobically (i.e. dry-sown, in an unpuddled field without standing water). Average annual rainfall in this area is 1300 mm but has an erratic distribution. During 2004, rainfall was adequate without any extended dry spells. The amount of rainfall recorded from May 1 to October 31 at the Northern Agriculture and Forestry Research Center (Houay khot) was 1038 mm.

There were four fertilizer treatments (main-plot) and six upland rice cultivars (sub-plot) in a split-plot design within each location. Fertilizer treatments consisted of (1) no added fertilizer (control), (2) N fertilizer (90 kg N/ha; urea), (3) P fertilizer (50 kg P/ha; triple superphosphate), and (4) N and P fertilizer (NP; as in treatment 2 and 3). The full amount of P and one-third of N were applied at planting time. The remaining N was applied equally at 30 and 60 days after planting. N and P fertilizers were applied in 1–2 cm deep furrows along contours and between the rice hills and then were covered with soil to avoid fertilizer movement. The six cultivars included three traditional cultivars from northern Laos (Vieng, Nok, and Mak hin sung), two improved cultivars from the Philippines (IR71525-19-1-1 and IR55423-01), and one from Indonesia (B6144-MR-6-0-0). Vieng has historically been used as a variety check in northern Laos. As noted earlier, Nok and Mak hin sung have been identified as high-yielding traditional cultivars. IR71525-19-1-1 is an improved, drought-tolerant upland rice variety primarily of tropical *japonica* background, and performed well in an observation nursery in Luang Prabang in the 2003 wet season (Lao-IRRI, 2003). IR55423-01 is an elite indica-derived upland rice line developed at IRRI in the Philippines whose high yield potential has been previously reported (George et al., 2001; George et al., 2002). B6144-MR-6-0-0 is an improved *indica* cultivar developed in Indonesia (Atlin and Lafitte, 2002), and now widely grown as an upland rice cultivar in Yunnan province, southern China. These improved cultivars have all been selected under at least moderate levels of inputs (Atlin, G.N., personal communication, 2004).

There were three replications at each location, and sub-plot size was 1.5 m × 3 m. Hill spacing was 25 cm × 25 cm.

Table 1
Description of the experimental locations in Luang Prabang province, Laos

Site information	Location		
	Houay khot	Somsanuck	Houay hia
Elevation (m)	330	320	605
Recent cropping history	Three-year fallow	Upland rice in the previous 2003 wet season	Three-year fallow
Situation	Hillside	Terrace at the foot of mountain	Upper part of mountain
Land preparation	Burning and tillage	Tillage	Burning
Mean grain yields of traditional cultivars under no fertilization (t/ha) ^a	1.1	1.5	2.3

^a Traditional cultivars include Vieng, Nok, and Mak hin sung.

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