

CHAPTER 12

The colored pericarp (black) rice of Laos

S. Appa Rao, J.M. Schiller, C. Bounphanousay, P. Inthapanya, and M.T. Jackson

Rice varieties with colored pericarp (other than white and red) are usually called “black rice” by the farmers of Laos. Black rice varieties have been reported from many countries of Asia, including China (Zhang et al 1995, Hoahua et al 1996, Gu and Xu 1992), India (Sastry 1978), Japan (Natsumi and Noriko 1994), and Vietnam (Quan 1999). Chaudhary and Tran (2001) also report on black rice from Sri Lanka, Indonesia, the Philippines, Bangladesh, Thailand, and Myanmar. Although the black rice of Laos does not constitute a significant proportion of the total rice production, it is widely grown throughout the country and is grown by most ethnic groups. For some ethnic groups, the way black rice is grown is strongly influenced by their traditions and beliefs. The consumption of black rice varieties is usually in the form of specialty foods (and alcoholic drinks) rather than as a staple food in the same way white rice is consumed.

Among the 13,192 samples of cultivated rice germplasm collected within Laos from 1995 to 2000 (Appa Rao et al 2002a), based on the information provided by the farmers at the time of collection, 459 accessions (3.5% of the collection) were classified as having colored pericarp (Appa Rao et al 2003). Although many of these varieties with a colored pericarp are called black rice (*Khao kam* or *Khao dam*) by Lao farmers, the color of the pericarp of most of these varieties varies from dark purple to light brown, rather than being black.

There has been little documentation of black rice in Southeast Asia generally, and for Laos there is almost no documentation of the presence and diversity of the black rice in the country. This chapter describes the diversity of the black rice collected in Laos from 1995 to 2000 (Appa Rao et al 2000), together with its characterization postcollection and some aspects of its production and use.

The planting of black rice in Laos

Black rice is grown in Laos under rainfed conditions in both upland and lowland environments. However, the reasons for growing black rice often differ between these two environments, reflecting differences in the ethnic composition of the populations between these environments. For ethnic groups in the Mon-Khmer language grouping

that are found mainly in the upland environment of the northern agricultural region, black rice is grown almost exclusively for use in spirit-related rituals. The black rice used in the various spirit-related ceremonies is usually true black rice (with a dark purple pericarp), rather than other forms of rice with a colored pericarp, such as “red” rice. There are also some rituals for which the use of black rice is specifically not acceptable, such as in commemorative ceremonies on behalf of the dead (for which sometimes a “false” black rice is used, produced by the blackening of white rice with charcoal dust). In most upland areas of Laos, small amounts of black rice are used for alcohol production, and often this alcohol is also used for spirit-related rituals.

In the lowland environment, black rice is more often grown to produce alcohol rather than for use in rituals and, relative to the upland environment, a much smaller proportion of lowland households grows black rice. In the lowland environment, there is also more direct consumption of various black rice-based products than is the case with communities in the upland environment. However, even in the lowland environment, where a high proportion of the population is Buddhist, there are taboos relating to the use of black rice in some Buddhist-related ceremonies. For example, black rice is never used in offerings to Buddhist monks or in making offerings in Buddhist temples. Such taboos do not extend to some of the other “colored” rice such as red rice. In both the upland and lowland environments, the older members of the different ethnic communities usually believe that alcohol made from black rice is far superior to alcohol made from white rice.

In both upland and lowland farming areas, only small areas of black rice are grown by individual households, and not all households in a community or village grow black rice. For some ethnic groups in the upland environment, it is often only the relatively more affluent families that celebrate various spirit-based rituals that grow black rice. Although small in area relative to the white-rice crop, in areas where black rice is predominantly used in spirit-related rituals, black-rice crops are regarded as being very important for the community, which collectively ensures that such crops are protected and thrive. For some ethnic groups for which black rice is used in animistic rituals, the village shamans who lead these rituals are often prohibited from both growing and consuming black rice and black-rice products.

The black rice of Laos, in both upland and lowland environments, almost exclusively has glutinous or waxy endosperm; Chaudhary and Tran (2001) report that most black rice found in other parts of Asia also has waxy endosperm. The usual quality characteristics that are the basis of the selection and consumption of white rice varieties (aroma and taste) are not always reflected in the black rice varieties of Laos, many of which are generally regarded as being inferior to white rice. In the uplands, the black rice varieties are usually all of relatively early maturity. Unlike the traditional white rice varieties, for which several varieties are often grown by individual households, usually no more than a single variety of black rice is grown.

Although included within the “colored pericarp rice,” “red” rice is usually not associated with spiritual taboos that exist for black rice in some ethnic communities. Red rice, unlike black rice, can be used when making food offerings to Buddhist monks and in Buddhist temples. Red rice, on milling, usually has a “colored” pericarp and

Table 1. Distribution of black rice samples collected from different growing environments and regions in Laos.^a

| Region | Wet season ^b | | | | Dry-season irrigated | Total samples | |
|---------|-------------------------|--------|---------|--------|----------------------|---------------|---------|
| | Upland | | Lowland | | | No. | (%) |
| | No. | (%) | No. | (%) | | | |
| North | 189 | (41.2) | 19 | (4.1) | 0 | 208 | (45.3) |
| Central | 110 | (24.0) | 66 | (14.4) | 0 | 176 | (38.4) |
| South | 35 | (7.6) | 40 | (8.7) | 0 | 75 | (16.3) |
| Total | 334 | (72.8) | 125 | (27.2) | 0 | 459 | (100.0) |

^aAll the black rice samples collected have glutinous endosperm. ^bNumbers in parentheses represent percentages (of total number of black rice samples).

is regarded as having superior eating quality to black rice. Also, the red rice found in Laos has both glutinous and nonglutinous endosperm. Sometimes the term “red rice” is also used to refer to the wild or intermediate (between wild and cultivated rice) forms of rice that can occur as weeds in cultivated rice fields.

Identification and classification of the black rice varieties of Laos

Using the passport data obtained at the time of collecting, and based on the information provided by farmers (up to 36 descriptors were used), the black rice collected from 1995 to early 2000 (Appa Rao et al 2000) was classified according to geographic distribution among the different provinces of Laos, production systems, maturity time, and endosperm type. Subsequent to being collected, it was also characterized for morphological and agronomic characteristics.

Representation of black varieties in the collection and among growing environments

Out of the 13,192 samples of traditional rice collected from 1995 to 2000, variety names are available for 12,411 samples (Appa Rao et al 2002b). Among these, 459 samples had names identifying them as black. Most (72.8%) black rice samples were collected from the upland environment, with the northern agricultural region accounting for 45.3% of the total (Table 1). No samples of black rice were collected in the dry-season irrigated environment, where 100% of the rice area is usually cultivated with improved white-rice varieties. The predominance of black-rice samples collected from the upland environment partly reflects the fact that, in the early 2000s, almost 100% of the upland rice area was still being sown to traditional rice varieties. However, at about the same time, for the wet-season rainfed lowland environment in the main rice-growing areas in the Mekong River Valley of central and southern Laos, improved varieties were being grown on 70% to 80% of the rice area. The largest number of black rice samples collected in the lowland environment came from the

Table 2. Distribution of black rice samples collected among ecosystems and provinces of Laos.^a

| Province/region | Total samples | Lowland ecosystem | | Upland ecosystem | |
|---------------------------------|---------------|-------------------|------|------------------|------|
| | | Samples | % | Samples | % |
| <i>Central region</i> | 142 | 63 | 13.7 | 79 | 17.2 |
| Borikhamxay (BK) | 23 | 5 | 1.1 | 18 | 3.9 |
| Khammouane (KH) | 25 | 21 | 4.6 | 4 | 0.9 |
| Savannakhet (SV) | 21 | 15 | 3.3 | 6 | 1.3 |
| Vientiane Province (VP) | 25 | 4 | 0.9 | 21 | 4.6 |
| Vientiane Municipality (VM) | 10 | 5 | 1.1 | 5 | 1.1 |
| Saysoumboun (SB) Special Region | 14 | 2 | 0.4 | 12 | 2.6 |
| Xieng Khouang (XK) | 24 | 11 | 2.4 | 13 | 2.8 |
| <i>Northern region</i> | 245 | 24 | 5.2 | 221 | 48.2 |
| Bokeo (BO) | 37 | 5 | 1.1 | 32 | 7.0 |
| Houaphanh (HP) | 23 | 5 | 1.1 | 18 | 3.9 |
| Luang Namtha (LN) | 37 | 4 | 0.9 | 33 | 7.2 |
| Luang Prabang (LP) | 44 | 2 | 0.4 | 42 | 9.2 |
| Oudomxay (OD) | 27 | 0 | 0 | 27 | 5.9 |
| Phongsaly (PL) | 31 | 4 | 0.9 | 27 | 5.9 |
| Sayabouly (SB) | 46 | 4 | 0.9 | 42 | 9.2 |
| <i>Southern region</i> | 72 | 38 | 8.3 | 34 | 7.4 |
| Attapeu (AT) | 18 | 11 | 2.4 | 7 | 1.5 |
| Champassak (CS) | 17 | 12 | 2.6 | 5 | 1.1 |
| Saravane (SV) | 25 | 12 | 2.6 | 13 | 2.8 |
| Sekong (SK) | 12 | 3 | 0.7 | 9 | 2.0 |
| Total | 459 | 125 | 27.2 | 334 | 72.8 |

^aAll samples had glutinous endosperm and all were collected from wet-season cropped areas in the lowland (predominantly rainfed) and upland (rainfed) environments.

central agricultural region (66 samples, representing 14.4% of the collection). The smallest number of black rice samples from the lowland environment came from the northern agricultural region (19 samples, representing 4.1% of the collection).

Geographic distribution of black rice

Black rice samples were collected from all provinces and from all 136 districts of Laos (Bounphanousay et al 2004, Appa Rao et al 2004) (Table 2). Among the provinces, Sayabouly had the highest number of samples in the collection (46), followed by Luang Prabang (44), Bokeo (37), and Phongsaly (37). All of these provinces are in the northern agricultural region, and for all four black rice prevailed in the upland environment rather than in the lowland environment. The provinces with the largest numbers of black rice samples collected from lowlands were Khammouane (21) and Savannakhet (15) in the central agricultural region and Champassak (12), Saravane (12), and Attapeu (11) in the southern agricultural region. The smallest numbers of samples were collected from Vientiane Municipality (10), Sekong (12), and the Saysoumboun Special Region (SR) (14). One reason for the relatively small number of black rice

samples collected from the Saysouboun SR was that one of the dominant ethnic groups in this area, the Hmong, has a preference for the consumption of nonglutinous rice and has little interest in glutinous black rice. Although Vientiane Municipality is a significant market for black rice, there is a preference for growing improved white rice varieties in this and nearby areas (where there are significant areas of irrigated production) on account of the high yield potential of the improved white rice varieties. Most traditional black rice varieties are relatively low yielding. The black rice sold in markets of the capital, Vientiane, is mostly imported from other provinces.

Naming of black rice varieties

As reported by Appa Rao et al (2002b) and in Chapter 10, most names of traditional rice varieties in Laos have three elements: the basic name, the root name, and a descriptor. The basic name *khao* indicates rice; the most common root name for black rice is *kam* or *dam* (black). Most of the varieties with the root name *kam* or *dam* have this unique characteristic. The descriptor allows further identification of a particular variety within the different groups. For example, *Khao kam do* is a black (*kam*), early (*do*) maturing variety. The population of Laos constitutes 48 recognized ethnic sub-groups (ADB 2001). Some of these ethnic groups sometimes use names other than *kam* or *dam* to indicate that a variety has purple (black) pericarp.

Within the 459 samples of rice that were collected and that had names indicating they had colored pericarp, the most common name was *Khao kam* (346 samples). However, not all samples with the root names *kam* or *dam* possess purple pericarp; in some instances, only the glumes were colored. In addition to the use of names that indicate directly that a variety is “black rice,” Lao farmers also use a range of other names to indicate that a variety has a colored pericarp. These names include reference to black birds (the crow), insects, animal dung, and other colorful names (Appa Rao et al 2000b) (Table 3).

Lao farmers used 72 distinct variety names for the 459 samples of rice that were collected and classified as black rice (Appa Rao et al 2004, Inthapanya et al 2003) (Table 3). All but four of these varieties were grown exclusively in either the upland or lowland environments; four varieties were being grown in both environments. Varieties with the same distinct name were sometimes collected from more than one district and/or province (as reflected in the data tabulated for individual provinces in Table 4), reflecting the relative numbers of black rice samples collected between the upland and lowland environments, and between agricultural regions and provinces. The largest number of distinct variety names was recorded in the upland environment, with the largest number in the northern agricultural region, in Luang Namtha, Luang Prabang, Phongsaly, Houaphanh, and Sayabouly.

Diversity within black varieties

Pericarp color of black rice varieties in Laos is generally not black, but varies from dark purple to various shades of purple, and to brown (Photo 12. 1). For most varieties, the purple pericarp color is sometimes associated with purple pigmentation on vari-

Table 3. Distinct black rice variety names and their classification and characteristics.^a

| Sample no. | Variety name of black rice | English meaning of name | LG no. | GC | PC | Ec | En | Mt | Pv |
|------------|----------------------------|-------------------------------|--------|-----|----|----|----|----|----|
| 1 | <i>Ba haheuy</i> | Purple pericarp | 8334 | 20 | 80 | U | G | L | AT |
| 2 | <i>Baksa</i> (Kam) | Purple pericarp | 4823 | 20 | 80 | U | G | M | SG |
| 3 | <i>Ble dou</i> | Black pericarp | 7472 | 52 | 88 | U | G | L | OD |
| 4 | <i>Ble sa</i> | Purple pericarp | 12339 | 20 | 88 | U | G | L | BO |
| 5 | <i>Dam beung</i> | Black spider | 1827 | 20 | 88 | U | G | M | VP |
| 6 | <i>Dam</i> (U) | Black | 3567 | 91 | 80 | U | G | L | LP |
| 7 | <i>Dam</i> (L) | Black | 13083 | 20 | 80 | L | G | M | XS |
| 8 | <i>Dam dang</i> | Black, variable | 2166 | 20 | 88 | L | G | M | AT |
| 9 | <i>Dam do</i> | Black, early (maturity) | 12312 | 90 | 80 | U | G | M | LP |
| 10 | <i>Dam ka</i> | Black, crow | 2757 | 20 | 88 | L | G | M | HP |
| 11 | <i>Dam kieng</i> | Black, glabrous | 13025 | 91 | 8 | U | G | L | SB |
| 12 | <i>Dam med gnao</i> | Black, long grain | 4346 | 20 | 88 | L | G | M | PL |
| 13 | <i>Dam mo</i> | Black | 13014 | 20 | 88 | U | G | L | SB |
| 14 | <i>Dam noi</i> | Black, small | 12936 | 20 | 88 | U | G | L | XK |
| 15 | <i>Dam nuk</i> | Black glumes | 3924 | 91 | 88 | U | G | M | OD |
| 16 | <i>Dam pee</i> | Black, late (maturity) | 12311 | 20 | 80 | U | G | M | LP |
| 17 | <i>Dam peek</i> (L) | Black winged (L) | 131 | 20 | 80 | L | G | L | AT |
| 18 | <i>Dam peek</i> (U) | Black winged (U) | 7332 | 20 | 80 | U | G | L | LN |
| 19 | <i>Dam py</i> | Very black | 13023 | 20 | 88 | U | G | L | SB |
| 20 | <i>Deb kom</i> | Purple pericarp | 5442 | 91 | 88 | U | G | M | SV |
| 21 | <i>Deb ram</i> | Purple pericarp | 5494 | 91 | 80 | U | G | E | SV |
| 22 | <i>Do dam</i> | Early (maturity), black | 12832 | 91 | 88 | U | G | E | VM |
| 23 | <i>Ea dam</i> | Black | 12780 | 91 | 80 | L | G | M | SK |
| 24 | <i>Ea kam</i> (L) | Black pericarp | 474 | 20 | 88 | L | G | M | CS |
| 25 | <i>Ea kam</i> (U) | Black pericarp | 8945 | 20 | 88 | U | G | E | CS |
| 26 | <i>Gnon na</i> (kam) | Purple pericarp | 11643 | 91 | 88 | U | G | L | BO |
| 27 | <i>Hiang</i> | Purple pericarp | 11479 | 20 | 88 | U | G | L | LN |
| 28 | <i>Hodo/kam peek</i> | Purple pericarp, winged | 2360 | 20 | 88 | U | G | E | BO |
| 29 | <i>Hodoko/Kam</i> | Purple pericarp | 4295 | 91 | 88 | U | G | M | PL |
| 30 | <i>Kaateu</i> | Purple pericarp | 8780 | 20 | 88 | U | G | M | AT |
| 31 | <i>Kam</i> (L) | Purple pericarp | 112 | 20 | 88 | L | G | M | AT |
| 32 | <i>Kam</i> (U) | Purple pericarp | 529 | 91 | 80 | U | G | M | SG |
| 33 | <i>Kam bo mee khon</i> | Purple, glabrous | 6648 | 90 | 88 | U | G | L | HP |
| 34 | <i>Kam do</i> | Purple pericarp, early | 3646 | 20 | 88 | U | G | E | LP |
| 35 | <i>Kam gnay</i> | Purple pericarp, big | 12217 | 20 | 88 | U | G | L | LN |
| 36 | <i>Kam hang</i> | Purple pericarp, awned | 6651 | 20 | 88 | U | G | L | HP |
| 37 | <i>Kam hai</i> | Purple pericarp, upland | 3763 | 100 | 88 | U | G | L | LN |
| 38 | <i>Kam kab khaw</i> | Purple pericarp, glumes white | 1386 | 20 | 88 | L | G | M | KM |
| 39 | <i>Kam kang</i> | Purple pericarp, medium | 5681 | 91 | 80 | U | G | M | VP |

Continued on next page

Table 3 continued.

| Sample no. | Variety name of black rice | English meaning of name | LG no. | GC | PC | Ec | En | Mt | Pv |
|------------|----------------------------|-------------------------------|--------|-----|----|----|----|----|----|
| 40 | <i>Kam khaw</i> | Purple pericarp, white | 10522 | 20 | 80 | U | G | E | LP |
| 41 | <i>Kam khie</i> | Purple (dung) pericarp | 6700 | 42 | 50 | U | G | L | HP |
| 42 | <i>Kam khie ngoua</i> | Purple (cow dung) pericarp | 130 | 20 | 88 | L | G | M | AT |
| 43 | <i>Kam khon</i> | Purple pericarp, hairy | 10355 | | 88 | U | G | E | BK |
| 44 | <i>Kam kieng</i> | Purple pericarp, glabrous | 9055 | 20 | 88 | U | G | L | HP |
| 45 | <i>Kam lay</i> | Purple pericarp, striped | 8648 | | | U | G | M | HP |
| 46 | <i>Kam leuang hang</i> | Purple pericarp, yellow awned | 9757 | 20 | 88 | U | G | M | SB |
| 47 | <i>Kam med gnao</i> | Purple pericarp, long grain | 1853 | 91 | 80 | U | G | M | VP |
| 48 | <i>Kam med pom</i> | Purple pericarp bold grain | 1851 | 91 | 88 | U | G | M | VP |
| 49 | <i>Kam mee khon</i> | Purple pericarp, hairy | 6647 | 20 | 88 | U | G | L | HP |
| 50 | <i>Kam na</i> | Black pericarp, lowland | 13192 | | | L | G | L | KM |
| 51 | <i>Kam noi</i> | Purple pericarp, small | 12237 | 91 | 88 | U | G | M | LN |
| 52 | <i>Kam peek</i> | Purple pericarp, winged | 7156 | 20 | 80 | U | G | E | PL |
| 53 | <i>Kam peng</i> | Purple pericarp, floury | 6740 | 42 | 88 | L | G | L | HP |
| 54 | <i>Kam peuak dam</i> | Purple pericarp, glumes black | 9477 | 91 | 88 | U | G | E | PL |
| 55 | <i>Kam peuak dam</i> | Purple pericarp, glumes black | 11994 | 100 | 80 | L | G | M | BO |
| 56 | <i>Kam peuak deng</i> | Purple pericarp, glumes red | 11995 | 54 | 80 | L | G | M | BO |
| 57 | <i>Kam peuak khaw</i> | Purple pericarp, glumes white | 9478 | 20 | 88 | U | G | L | PL |
| 58 | <i>Kam peuak khaw</i> | Purple pericarp, glumes white | 11996 | 20 | 88 | L | G | M | BO |
| 59 | <i>Kam pon</i> | Purple (mixed) pericarp | 12709 | | | U | G | M | SB |
| 60 | <i>Ko sareuay</i> | Purple pericarp | 5467 | 100 | 88 | U | G | M | SV |
| 61 | <i>Koda</i> | Purple pericarp | 4323 | 91 | 80 | U | G | M | PL |
| 62 | <i>Kok kam</i> | Plant black | 9737 | 91 | 88 | U | G | M | SB |
| 63 | <i>Kou cha</i> | Purple pericarp | 5423 | 52 | 88 | U | G | M | SV |
| 64 | <i>Mak eu</i> | Pumpkin fruit | 5461 | 91 | 88 | U | G | E | SV |
| 65 | <i>Nia</i> | Purple pericarp | 12417 | 90 | 88 | U | G | E | PL |
| 66 | <i>Niaw dam</i> | Glutinous, black | 6874 | 91 | 80 | U | G | M | XK |
| 67 | <i>Pa siev dam</i> | Tiny carp, black | 11812 | 20 | 88 | U | G | E | SB |
| 68 | <i>Pee dam</i> | Late black | 12904 | 91 | 80 | U | G | L | VP |
| 69 | <i>Peek dam</i> | Winged black | 7401 | 91 | 80 | U | G | L | LN |
| 70 | <i>Po</i> | Purple pericarp | 8286 | 91 | 80 | U | G | L | CS |
| 71 | <i>Se phong kanto</i> | Purple pericarp | 4425 | 20 | 88 | U | G | L | PL |
| 72 | <i>Tou valien</i> | Purple pericarp, awned | 5419 | 20 | 88 | U | G | M | SV |

^aLG no. = Lao Germplasm Bank no., GC = glume color, PC = pericarp color, EC = ecosystem, L = lowland, U = upland, En = endosperm type, G = glutinous, Mt = maturity, E = early, M = medium, L = late, Pv = province (refer to Table 2).

Table 4. Distribution of black rice (Khao kam) variety names in different ecosystems and provinces in Laos.

| Region/province | No. of samples | | Distinct black rice variety names | | |
|----------------------------|-----------------------|--------------------------|-----------------------------------|-----------------|---------|
| | Total collected (no.) | Black rice samples (no.) | Total names | Number of names | |
| | | | | Lowlands | Uplands |
| <i>Northern region</i> | 5,915 | 142 | 67 | 12 | 55 |
| Bokeo | 686 | 23 | 9 | 4 | 5 |
| Houaphanh | 631 | 25 | 11 | 3 | 8 |
| Luang Namtha | 858 | 21 | 10 | 1 | 9 |
| Luang Prabang | 1,244 | 25 | 10 | 1 | 9 |
| Oudomxay | 848 | 10 | 5 | 0 | 5 |
| Phongsaly | 664 | 14 | 11 | 2 | 9 |
| Sayabouly | 984 | 24 | 11 | 1 | 10 |
| <i>Central region</i> | 4,623 | 245 | 33 | 14 | 19 |
| Xieng Khouang | 561 | 37 | 6 | 2 | 4 |
| Borikhamxay | 595 | 23 | 4 | 1 | 3 |
| Khammouane | 866 | 37 | 5 | 4 | 1 |
| Savannakhet | 988 | 44 | 3 | 2 | 1 |
| Vientiane Mun. | 485 | 27 | 4 | 2 | 2 |
| Vientiane Prov. | 787 | 31 | 8 | 1 | 7 |
| Saysoumboun Special Region | 341 | 46 | 3 | 2 | 1 |
| <i>Southern region</i> | 2,652 | 72 | 24 | 8 | 16 |
| Attapeu | 640 | 18 | 7 | 4 | 3 |
| Champassak | 842 | 17 | 5 | 2 | 3 |
| Sekong | 396 | 25 | 3 | 1 | 2 |
| Saravane | 774 | 12 | 9 | 1 | 8 |
| Total | 13,190 | 459 | 124 | 34 | 90 |

ous plant parts, such as the glumes, leaf blade, leaf sheath, midrib, peduncle, panicle (Photo 12.2), and spikelets (Photo 12.3). However, not all varieties with purple coloring in various plant parts have grain with colored pericarp. Similarly, for varieties in which the pericarp is colored, other plant parts, such as glumes and leaves, may not be purple. Black rice is found in both indica and japonica groups (Choudhary and Tran 2001). Roder et al (1996) reported that enzymatic analysis of part of a collection of traditional upland varieties obtained in northern Laos in 1991-93 indicated that more than 90% of the entries belonged to the japonica group. Although black rice was not specifically identified as part of this collection, it is unlikely that the black upland varieties of Laos would differ from the majority of the other upland varieties.

Characterization of black varieties

Out of the 459 accessions classified as having a purple pericarp, 241 were grown in the 1999 wet season at the Agricultural Research Center (ARC) in Vientiane Municipality for characterization and classification of their morphological and agronomic

characteristics. For this characterization, both lowland and upland varieties were grown under good management conditions, including irrigation.

Data were recorded according to the standard evaluation system for rice (IRRI 1996). For a sample of 241 varieties, days to flowering ranged from 86 to 145, with a mean of 110; however, most accessions flowered within 120 days and, in general, upland varieties flowered earlier than lowland varieties. This earlier flowering (and subsequent earlier maturity) probably reflected specific selection and adaptation to the uplands, where the soils can rapidly dry out with the end of the wet-season rains, and where most varieties have to be harvested before the majority of lowland varieties. Culm length ranged from 61 to 155 cm, with a mean of 95 cm. Most accessions were very tall, with only nine being shorter than 70 cm. The later-maturing, strongly photoperiod-sensitive varieties were generally taller than the early-maturing varieties. The number of productive tillers varied from 2 to 11, with a mean of 5.5 per hill. In general, upland varieties usually produce fewer tillers than most lowland varieties. When dibble sowing rice in the upland environment, more seed is usually sown per hill than plants transplanted per hill in the lowland environment. Flowering within varieties was synchronous, with the number of productive tillers being greater in the more photoperiod-sensitive, later-maturing varieties. Panicle length varied from 15 to 33 cm, with a mean of 24 cm. Considerable variation was observed for spikelet characteristics such as shape, length, width, and thickness, and color of glumes (Photo 12.3) and pericarp. Steamed black rice was dark purple in color and was shining brightly, giving an appearance of “black pearl” (Photo 12.4). Grain size, a highly heritable character, also showed considerable variation among different samples. For a sample of 198 varieties, 100-grain weight was 2.3 to 4.4 g, with a mean of 3.1. Many of the glutinous black varieties have grains that are globular in shape. In a 2002 wet-season assessment of yield for 45 Lao black rice varieties, yield ranged from 1.4 to 3 t ha⁻¹ (Inthapanya et al 2003).

Nutritional value of black rice

Black rice generally draws the attention of rice consumers because of its unusual color. However, in Laos, there is a general perception that black rice is inferior in quality to white rice. This contrasts with the situation in parts of southwest and central China, where black rice varieties have been developed that are reported to be of good quality and high yielding, and have multiple resistance (Chaudhary and Tran 2001). Some of these Chinese black rice varieties are reported to have higher protein, higher fat, and higher crude fiber contents than the common or white rice varieties as well as being rich in lysine, vitamin B₁, calcium, iron, zinc, and phosphorus (Chaudhary and Tran 2001, Gu and Xu 1992). However, it is acknowledged that the higher values for some of these characteristics may not necessarily always be genetically based but may also reflect processing (such as milling) methods. In Laos, black rice is often manually pounded to remove the glumes and consumed after minimum polishing or without polishing (Photo 12.1). As the aleurone layer where the vitamins and minerals, besides protein and fat, are located is not completely removed in black rice, the resulting product is often of higher nutritional value than polished white rice. It has also been

reported (Quan 1999) that beverages made from black rice produced after fermentation can sometimes be of high quality. In Laos, black rice is also sometimes used for commercial production of fermented alcoholic beverages, and its older consumers regard it as a superior product to that produced from white rice.

Inheritance of colored pericarp

The intensity of pericarp color in rice depends on the presence of various kinds of pigments and their proportions in the pericarp. Among the several pigments present in the pericarp, glycoside cyanidin is the major one (Haohua et al 1996). These pigments have been found to be quite stable under normal temperature, light, and processing conditions (Haohua et al 1996). Reports on the mode of inheritance of pericarp color in black rice are few. Sastry (1978) reported that crosses between white and red pericarp parents produced F_1 plants with a red pericarp, revealing that red pericarp color was dominant over white. In the F_2 generation, the plants segregated in a ratio of 3 red to 1 white, suggesting that a single dominant gene controls red pericarp color in rice. On the other hand, crosses involving several parents with varying amounts of pigments (varying intensity of purple color) have showed that the intensity of color in the plants varies, depending on the number of genes present in the F_1 plants, the alleles for high pigment content being dominant to those for low pigment content, indicating additive-dominance (Zhang et al 1995). These authors report that two pairs of genes were found to control pigment content in the pericarp, with high pigment content (colored pericarp) being dominant to low pigment content (light-colored pericarp). The deep purple pericarp was expressed as dominant over purple, with the light purple pericarp being dominant to nonpigmented (white), indicating that two pairs of dominant genes control black pericarp pigmentation. As either one or two dominant genes control intensity of pericarp color in rice, it is easy to transfer colored pericarp character into high-yielding modern varieties.

Future use of the black glutinous varieties of Laos

As a result of the rice germplasm collecting and conservation program undertaken in Laos from 1995 to 2000, the country has one of the most extensive collections of traditional black rice germplasm of any single country where germplasm collecting and conservation have been done. Preliminary evaluation of some of this black rice germplasm base also indicates that there is significant diversity in many characteristics within the collection. Accessions have been identified that are extra vigorous, early flowering, and short-statured; some also have high tillering capacity, long panicles, and heavy grains, in addition to having a generally desirable phenotypic acceptability. However, this initial assessment is preliminary and was made under lowland conditions (whereas most of the varieties in the collection were collected in the rainfed upland environment). Considerable work remains to be done in properly evaluating and characterizing the Lao black rice germplasm collection in the environment in which it has traditionally been grown.

Despite projections of a future significant increase in rice needs (and therefore production demand) to meet the increasing population in 2020 (when projections of 7.7 million suggest that rice consumption requirements will need an annual production of at least 2.6 million tons of rice paddy), this increased demand will be mainly for white rice, perhaps with an increased proportion of nonglutinous rice relative to the early 2000s. The consumption of black rice within Laos will likely continue to be for the specialty foods for which it is currently grown and used. Perhaps, with greater urbanization of the population, consumption in traditional areas of production might decline. The export market for black rice is very specialized and also limited in size for the boutique rice in whose category black rice falls. It will be important for Laos to maintain the genetic resource base of black rice that it has. However, there may be little potential return from a significant allocation of limited research resources for the development of specialized black rice varieties through breeding. Rather, the full characterization of the collection, and subsequent evaluation in appropriate environments, to allow the identification of varieties that best fit specific growing conditions and environments in Laos should bring the greatest benefits.

References

- ADB (Asian Development Bank). 2001. Participatory poverty assessment, Lao People's Democratic Republic. Manila (Philippines): ADB. 108 p.
- Appa Rao S, Bounphanousay C, Schiller JM, Jackson MT. 2000. Summary of passport information of rice germplasm collected in the Lao PDR between 1995 and 2000. Vientiane, Laos, Lao-IRRI Project. 575 p.
- Appa Rao S, Bounphanousay C, Schiller JM, Jackson MT. 2002a. Collection, classification and conservation of cultivated and wild rices of the Lao PDR. *Genet. Res. Crop Evol.* 49:75-81.
- Appa Rao S, Bounphanousay C, Schiller JM, Alcantara AP, Jackson MT. 2002b. Naming of traditional rice varieties by farmers in the Lao PDR. *Genet. Res. Crop Evol.* 49:83-88.
- Appa Rao S, Bounphanousay C, Inthapanya P. 2004. Collection, classification and characterization of traditional black rice varieties of the Lao PDR. *Lao J. Agric. Forest.* 7:27-34.
- Bounphanousay C, Appa Rao S, Inthapanya P, Douangvila K. 2004. Collection, classification and characterization of traditional black rice varieties of the Lao PDR. Lao-IRRI Project, Vientiane, Lao PDR. 51 p.
- Chaudhary RC, Tran DV. 2001. Speciality rices of the world: a prologue. In: Specialty rices of the world: breeding, production, and marketing. Enfield, N.H. (USA): Science Publishers, Inc. and FAO. p 3-12.
- Gu D, Xu M. 1992. A study of special nutrient of purple black glutinous rice. *Sci. Agric. Sin.* 25(5):36-41.
- Haohua HE, Pan X, Zao Z, Liu Y. 1996. Properties of the pigment in black rice. *Chinese Rice Res. Newsl.* 4(2):11-12.
- Inthapanya P, Bounphanousay C, Voladeth S. 2003. Lowland black rice (Khao kam). *Lao J. Agric. Forest.* 7:17-25.
- IRRI (International Rice Research Institute). 1996. Standard evaluation system for rice. Manila (Philippines): IRRI. 52 p.

- Natsumi T, Noriko O. 1994. Physicochemical properties of Kurogome, a Japanese native black rice. Part 1. Bull. Gifu Women's Coll. 23:105-113.
- Quan LH. 1999. Selection of yeast for beverage production from black rice. Nong Nghiep Cong Nghiep Thuc Pham 8:375-376.
- Roder W, Keoboulapha B, Vannalath K, Phouaravanh B. 1996. Glutinous rice and its importance for hill farmers in Laos. Econ. Bot. 50(4):401-408.
- Sastry SVS. 1978. Inheritance of genes controlling glume size, pericarp color, and their inter-relationships in indica rices. Oryza 15:177-179.
- Zhang M, Peng Z, Xu Y. 1995. Genetic effects on pigment content in pericarp of black rice grain. Chinese J. Rice Sci. 9(3):149-155.

Notes

Authors' addresses: S. Appa Rao, Genetic Resources Center, IRRI, DAPO Box 7777, Metro Manila, Philippines; J.M. Schiller, School of Land and Food Sciences, University of Queensland, St. Lucia 4072, Australia; C. Bounphanousay and P. Inthapanya, National Agriculture and Forestry Research Institute, Ministry of Agriculture and Forestry, Vientiane, Lao PDR; M.T. Jackson, Program Planning and Communications, IRRI, DAPO Box 7777, Metro Manila, Philippines.

Acknowledgments: The authors gratefully acknowledge the farmers of Laos who provided not only samples of their valuable seed for conservation but also their invaluable knowledge about the traditional rice varieties of the country. Special acknowledgment is due to the many officials within the Ministry of Agriculture and Forestry of Laos for their role in collecting much of the information reported in this chapter. The financial support of the Swiss Agency for Development and Cooperation (SDC) to the project that undertook the collection of traditional varieties for conservation and use is also acknowledged.