

Encounter of Cambodian rice farmers with war and rice diversity (unattributed)

'There is, moreover, a certain kind of land where the rice grows naturally, without sowing. When the water is up to one fathom deep, the rice keeps pace with its growth. This I think, must be a special variety.'

Chou Ta-Kuan (Chinese traveller), on his 1296-97 visit to Cambodia.

1 INTRODUCTION

According to the respected agricultural scientist M.S. Swaminathan, rice and poverty go together. However, this has not been true for Cambodia, which has been rich and famous **due** to its rice.

Pre-war Cambodia was a prosperous Khmer Kingdom. Farmers cultivated thousands of varieties of rice to meet both local consumption and export needs. However, the civil war and subsequent disruptions broke this cycle.¹ Conflict lasted almost three decades in both upland and deepwater rice growing areas. There was no germplasm storage facility and the international community feared potential loss of native rices for Cambodia itself as well as for the biological heritage of mankind.

This article examines the rice situation in Cambodia pre-war, during the war and now, and suggests some steps which research and development organisations might take to alleviate potential varietal stress. It begins with a brief section on rice diversity, moves on to provide more detail about rice cultivation in Cambodia and then describes key features of the Cambodian war. Finally it looks at the effect of war on rice diversity in Cambodia and examines some responses to the situation.

2 RICE DIVERSITY

Oryza sativa (rice cultivated the world over) originated in the humid tropics of south and southeast Asia, 75-90 million years ago (Oka, 1988). Based on his study of extensive collections of rice accessions, N.I. Vavilov proposed that rice originated in an area he termed the Hindustan Centre of Origin (Vavilov, 1951). This area extends from eastern India to Cambodia, and it is here that the greatest genetic diversity of rice is found (Chang and Li, 1991; IRRI, 1978).

Rice has been under domestication for over 10,000 years. During this time it has evolved into various ecotypes and landraces under the influence of both natural and farmer selection. The genetic diversity has been preserved but has also been evolving to match the agro-ecologies of rice cultivation (rice grows from 50° N to 40° S of the equator, from 2,500 m in the hills to below sea level, from alkaline to acidic soils, from mountainous, dry uplands to 6 m of deepwater). Thus the tremendous genetic variability in rice remains.

3 RICE CULTIVATION IN CAMBODIA

Located between 102°-108° E and 10°-15° N, Cambodia lies between Vietnam on the east and Thailand on the

west. It has a land area of 181,000 km² and nine million inhabitants. Day length varies from 11 hours 52 minutes to 13 hours 11 minutes (without twilight). Mean maximum and minimum temperatures range between 30-36°C and 21-25°C, respectively. Annual rainfall is 1,343 mm with the rains falling mostly during April to November. Impoverished Cambodian soils are low in organic carbon and phosphorus and are acidic with low cation exchange capacity.

Cambodia is a country of continuous rice. Rice occupies 93% of the cultivated area of Cambodia (c. two million ha) and approximately 85% of the population are in some way involved in rice cultivation. Thus agriculture in Cambodia is nothing but rice culture.

Of the rice that is currently cultivated approximately 10% (by area) is dry season, 2% rainfed upland, 8% deepwater and 80% rainfed lowland (15% early, 30% medium, 35% late). Yields are poor (1.5 t/ha) and while Cambodia was a significant rice exporter in the mid-1960s it now has an annual shortfall of about 50,000 tons of rice. Per capita Cambodia is the third highest rice consumer in the world (172 kg/head/annum) and with a 2.7% population growth rate, demand for rice is expected to rise by 33% over the next 10 years.

It is currently estimated that there are about 4,000 different varieties of rice grown in Cambodia (Chaudhary, 1993; Chaudhary and Sahai, 1991) with varieties being selected according to season and land situation (Coyad, 1950; Fujisaka, 1988). Rainfed upland varieties are grown in the upper slopes and mountainous regions, deepwater rices are grown around depressions and river basins (Mekong and Tonle Basac). In other areas various types of rainfed lowland rices are grown. Depending upon the availability of irrigation, some irrigated rices are grown, mostly during the dry season. Table 1 shows the area under various types of rice. As will be discussed below, this represents a significant change from the pre-war years.

Varietal selection

Varietal choice and field situation

Research which took place before the war in Cambodia (Coyad, 1950; Delvert, 1961; Tichit, 1981) showed the location or situation of a field with regard to topography and hydrology to be the main factor determining a farmer's choice of variety to plant. Soil types are a secondary consideration as these tend to match the topography.

Table 1. Rice area under various ecologies in Cambodia during 1967 (Tichit, 1967) and in 1994
Figures in parenthesis are percent of the total

Rice cultural type	Area in 1967 (ha)	Area in 1994 (ha)	Ecosystem peculiarities
Early rice (<i>Srau Sraŋ</i>)	7,800 (3%)	313,531 (16%)	Mostly rainfed, some irrigated
Medium rice (<i>Srau Kandaŋ</i>)	313,700 (13%)	645,466 (33%)	Rainfed lowland, good soil
Late rice (<i>Srau Thnagun</i>)	1,568,100 (64%)	704,205 (36%)	Rainfed lowland, heavy soil
Deepwater rice (<i>Srau Laungtauk</i>)	390,000 (16%)	91,421 (5%)	Flood prone, dangerous areas
Upland rice (<i>Srau Phnom</i>)	?	37,381 (2%)	Mountain, drought prone, dangerous
Dry season (<i>Srau Prong</i>)	163,900 (7%)	155,000 (8%)	Mostly irrigated, high productivity

An average farm family is said to use anywhere from five to ten varieties (Coyad, 1950; Delvert, 1961; Tichit, 1981; Lando and Solieng, 1994b). Tichit (1981) notes: 'In order to distribute risk, he [the farmer] uses several varieties locally adapted to the hydrological conditions and soils in the fields he exploits, and this can often be a combination of several types of rice culture: for example, a parcel of early transplanted rice, harvested in November (the period of scarcity) and, in low fields, the planting of a variety, indeed floating rice, which is harvested in January or February.' Delvert (1961) wrote: 'The diversity of varieties, without any doubt, diminishes the natural risk of a bad harvest'.

Society in Cambodia is structured on matriarchal lines and it is the women who are more knowledgeable about topography and varietal choices. Although every *khum* or *phum* (village or commune) will have some acknowledged rice experts, most families have some expertise. These women decide which varieties should be retained for planting the subsequent year. The best crops of these varieties are then identified and healthy panicles are selected and stored. This practice, directed by women, has maintained the purity of traditional varieties. Varietal exchanges with other areas have taken place on a limited scale with the assistance of women-experts (Delvert, 1981; Lando and Solieng, 1994c).

Varietal choice and culinary qualities

Farmers also take into account culinary qualities, such as good volume expansion and flavour and use for special dishes like glutinous rice, when they select varieties to grow (Delvert, 1961). In the survey conducted by Lando and Solieng (1994c), volume expansion (meaning that a small amount of rice can feed a large family) was cited as one of the main criteria for varietal selection. In their detailed analysis, these authors identified the following factors behind varietal choice (in descending order of importance): yield; field adaptation; maturity; eating quality; sale price; agronomic

characteristics; submergence tolerance; and drought tolerance.

Varietal choice and photoperiod sensitivity

Contrary to common belief, the overwhelming majority of Cambodian varieties are photoperiod-sensitive (though the degree of sensitivity varies from slight to strong).² Out of the 1,594 evaluated entries of currently grown varieties, 97.6% proved to be photoperiod-sensitive (74.9% strongly sensitive, 18.2% essentially sensitive, 3.9% slightly sensitive) and only 2.4 % are insensitive. This is well above the average; for example, out of about 80,000 accessions stored in the genebank of the International Rice Research Institute at Los Baños, only about 20% are considered photoperiod-sensitive.

This unusual incidence of photoperiod-sensitivity suggests that there is strong selection by nature and/or by farmers for this trait. In different rice environments, the variation in the number of hours of sunlight is related to a number of environmental factors critical to crop growth, notably patterns of rainfall, temperature, humidity and light intensity. In Cambodia, photoperiod-sensitivity allows rice varieties to synchronise their flowering with the recession of the flood, to avoid setting seed in periods when damage by birds is likely, and to mature before the cold sets in. Farmers have adjusted their practices around the photoperiod sensitivity of rice. It provides a measure of flexibility in seeding (April to July) and transplanting (20-100 day-old seedlings).

4 KEY FEATURES OF THE CAMBODIAN WAR

Cambodia, known as the country of 'smiling people', had been a prosperous empire in the beginning of its recorded history, from the first till the sixth century AD. Khmer Kings used to boast that they had plenty of rice in the fields and fish in the water, and that no one could defeat them. The Khmer kingdom was at its zenith

during the twelfth century but then decline set in. By the end of the 19th century the country had shrunk to two-thirds of its original size and in 1863 it was colonised by the French. The period of French colonial rule, from 1863 to 1954, saw great population movement, loss of geographical areas, political uncertainties and wars with neighbours. In contrast, the Sihanouk period, 1954 to 1970, was characterised by relative stability. This was the era in which Cambodia was a rice exporting country (rice areas reached a maximum of 2.5 million ha compared to c.2 million today). However, in an effort to stabilise his position, Prince Sihanouk allied himself variously with the United States and Vietnam. The continuous shifts in the policy, from left to right to centre, and increasing central control, led to severe economic problems during the 1966-1969 period. Black market trade in such essential goods as rice was rampant.

Eventually these economic and political stresses resulted in the appointment of the American-backed Marshall Lon Nol, and a virtual coup d'état and the ousting of Prince Sihanouk (who fled to China in 1970). Subsequent political manoeuvring and mismanagement created further hardship for Cambodia's people; rice production fell to an all-time low and corruption skyrocketed. Even massive US support to Lon Nol's corrupt government could not prevent its downfall. Intensified fighting between Cambodian Khmer Rouge and Vietnamese guerrillas, sometimes backed by US and South Vietnamese forces, disrupted peasant life. Massive round-the-clock American bombings during 1973-1975 further paralysed the country. More bombs were dropped over Cambodia during these three years than during the whole of World War II. Not surprisingly, cultivation came to a virtual halt (with distant plots, in particular, being abandoned) and when the Americans evacuated Lon Nol to Hawaii in 1975 not much was left in Cambodia but bomb craters and empty cities. The state of rice cultivation and the plight of rice farmers can well be imagined.

Agriculture during the war

When the Khmer Rouge emerged victorious in 1975, the policy of 'cooperative farming' and mobilising city people (New People) to 'educational camps' was immediately imposed. Only a week after Lon Nol's flight, the entire population of Phnom Penh and other major cities was evacuated and resettled in rural agricultural collectives under Khmer Rouge control. Villagers from one area were systematically moved to other, unfamiliar localities. Individual rights to property were abolished and communes were created to handle production.

The Khmer Rouge attempted to transform Cambodia into a fully irrigated rice farming country. Massive plans for canal and reservoir construction were drawn up, and cultivation of deepwater rice and rainfed lowland rice was abandoned in favour of irrigated rice. However, within the short period of Khmer rule it was not possible to fulfil the irrigation plans using only manual labour, causing further problems.

Newly-arrived city and rural dwellers, unaware of the suitability of different rice varieties and cultivation techniques, often mismatched varieties with the local land topography. It is no surprise then that the period of civil war, 1970-1975, and the subsequent Pol Pot regime (1975-1979) profoundly affected deepwater rice cultivation in Cambodia. Overall rice production fell drastically and strict rationing was imposed - each person would receive 'one-cup of rice soup' per day. More than 1.5 million people died (due to murder, starvation and other hardships). This situation persisted until 1979 when Vietnamese forces ousted the Khmer Rouge and installed the government of Hun Sen.

Around 1980, a number of Vietnamese rice experts were brought to Cambodia to help resurrect rice production. Once the process of rebuilding ravaged fields began, exiled Cambodian farmers began to return home, mostly from Vietnam. Some brought with them their original seed varieties which they had taken with them to grow in Vietnam. For the next ten years, until UNTAC (United Nations Transitional Authority in Cambodia) came into being in 1990, the Hun Sen government took many steps to reform agriculture. The right to own property was reintroduced; farming was encouraged through *Krom Samaki* (cooperatives), and international aid agencies were allowed to enter Cambodia. Despite this opening-up process, the era of the Green Revolution which had such a profound impact on other south and east Asian countries almost entirely bypassed Cambodia. Even the miracle rice IR 8 did not reach this country.

Statistics on population and the area under rice cultivation offer some unique insights into the effects of the war in Cambodia. During 1969, when Cambodia was a prosperous rice-exporting country, there were about 2.5 million ha under rice cultivation and 6.7 million inhabitants in the country (Table 2). During the following years, population grew to a peak of 7.5 million, but by 1979 it had declined to 6.1 million due to massive killing and large-scale emigration. The area under rice cultivation fell to a low of 0.774 million ha at about this time due to the multiple dangers associated with war and actual damage caused by fighting, bombing, etc.

Cambodia is perhaps the best example of the worst things that wars can accomplish: massive killings and, through deliberate agricultural disruptions, the loss of significant crop genetic diversity.

5 VARIETAL LOSS DURING THE WAR

How many rice varieties were actually lost during all these events is a matter of conjecture and debate but all agree that the number was significant. Some 20 years later, farmers still lament the loss of certain varieties. For instance, some still ask: 'Can I get my *Kanlong Phnom*' (a deepwater rice variety which had adapted to the vagaries of the deepwater environment). According to the farmers this variety never failed their ancestors, and they believe that it will never fail them. Attempts were made to find the variety in national and international genebanks but to no avail. There are many

Table 2. Area planted to rice and population in Cambodia

Year	Area planted (000 ha)	Population (000)
1962	2,286	5,740
1963	2,332	NA
1964	2,376	NA
1965	2,344	NA
1966	2,414	NA
1967	2,513	6,400
1968	2,473	NA
1969	2,450	6,700
1970	1,880	NA
1971	1,548	NA
1972	NA	NA
1973	NA	NA
1974	550	7,500
1975	NA	NA
1976	NA	NA
1977	NA	NA
1978	1,450	NA
1979	774	6,100
1980	1,443	6,300
1981	1,350	6,591
1982	1,680	6,782
1983	1,755	7,133
1984	1,390	7,330
1985	1,600	7,600
1986	1,618	7,813*
1987	1,378	8,032*
1988	1,712	8,257*
1989	1,630	8,488*
1990	1,410	8,726*
1991	1,571	8,970*
1992	1,719	9,221*
1993	1,857	9,479*
1994	1,946	9,744*
1995	1,946	10,017*

other varieties like *Kanlong Phnom* which farmers still cry for but which are nowhere to be found (Lando and Solieng, 1994a, b).

There are few precise surveys of varietal loss. However, Lando and Solieng (1994b) conducted work in the Prey Kabas area of Takeo district, a deepwater rice area. According to the survey, the 15 most prominent and adapted deepwater rice varieties were all lost during the Pol Pot period.³ The varieties which farmers were currently growing at the time had all been introduced from unknown sources and other provinces.

To summarise, there are three principal causes of extensive rice varietal loss in Cambodia:

- (i) In the absence of any organised seed production and distribution systems farmers maintain their varieties by annual growing. If cultivation is suspended, even for one year, the seeds lose their

viability and varieties may be lost for good.

- (ii) Large-scale movement of farmers from one part of the country to another and movement of urban dwellers to the countryside took place. This meant that many were new to the areas in which they subsequently farmed. They were given unfamiliar seed to plant and they frequently experienced total crop failure. Thus many varieties failed to grow or to produce seeds and were lost for ever. The situation was most grim from 1975 to 1979 when population movement was at its height. Farmers lost contact with their own varieties and could not match the ecological diversity of the field with the varieties they were asked to sow.
- (iii) During the Pol Pot era of 1975 to 1979, only irrigated rice cultivation was permitted. Farmers were forbidden to grow deepwater (floating) and late rices. The area under deepwater rice cultivation pre-war had been substantial (estimated at over 500,000 ha in 1930 (Hellei, 1970)). This declined to a near zero level during the Pol Pot era (Tichit, 1981). Even post Pol Pot cultivation of deepwater areas was suspended due to floating mines and continued fighting. Only those deepwater varieties which were taken to Vietnam and cultivated there were saved. The same story held true for upland and rainfed rice, the cultivation of which was also outlawed. Subsequently farmers found it hard to maintain and rejuvenate their stocks during a period of frequent movement.

6 EFFORTS TO PRESERVE AND RESTORE RICE VARIETAL DIVERSITY

Germplasm collections

Before the war, there were no formal germplasm storage facilities in Cambodia. Fortunately, however, several collections of rice had been amassed by geneticists from IRRI, who had been working in conjunction with Cambodian national scientists. IRRI has the global mandate for rice research and also houses the International Rice Gene Bank (IRG), which stores global rice germplasm. In December 1972, IRRI had sent a collection expert to Cambodia. He made contact with two research stations (Bek Chan and Toul Samrong) and organised a local team to collect rice germplasm. During the scientist's second trip, in January 1973, the war broke out in Cambodia and he was forced to return to the Philippines precipitously. With him, he happily brought back the collections maintained at both Bek Chan (196 samples) and Toul Samrong (264 samples), as well as some 40 samples collected directly from farmers' fields (Perez, 1973). This very valuable collection raised the number of Cambodian accessions in the IRG from 55 to 555.

IRRI made subsequent, vital and unique collections of Cambodian germplasm. A second organised collection of rice germplasm was made in 1989-90, out of which 1,270 new accessions were catalogued (Table 3). In

Table 3. Number of Cambodian rice germplasm collected, evaluated, catalogued and preserved, 1989-93

Year	Collected	Evaluated	Catalogued	Preserved at:	
				Cambodia	IRGC Philippines
1989	1,358	1,358	-	-	-
1990	-	1,270	-	1,252	1,256
1991	1,600	348	1,270	348	340
1992	2,000	509	509	61	61
1993	1,680	319	319	-	-
Total	6,638	3,804	2,098	1,661	1,657

1991, a third collection "was made, yielding 348 new varieties. There was a fourth collection in 1992 (of 509 new accessions), followed by a fifth collection (of 319 accessions) during 1993. It is estimated that there are about 4,000 traditional varieties of rice under cultivation in Cambodia. The IRRI and Cambodian National teams have been able to collect and preserve 2,489 of these in the IRRI Gene Bank in Cambodia and at IRG in the Philippines (Chaudhary, 1991). A third set is maintained in black box storage at Fort Collins in the USA. (Chaudhary and Sahai, 1991). The Cambodian material is being carefully catalogued and evaluated so that it can be more efficiently used to help meet breeders' and farmers' needs for adapted and diverse germplasm (e.g. Sahai *et al.*, 1992a, b). Some of this material is already used in on-farm trials.

Breeding and selection strategies

Despite the preservation of Cambodian material in several gene banks, breeders are still concerned about the possible narrowing of diversity on farm. This is due both to varietal loss during the civil disruptions, and to the fact that successful rice research programmes in Cambodia are starting to release varieties which farmers find highly attractive, and which could be widely sown over large expanses - thereby promoting varietal uniformity.

Multiple strategies need to be developed and promoted relatively quickly to maintain biodiversity on-farm. Official release of some of the more productive farmer varieties, saved by collectors and then rigorously evaluated, has already been identified as an important step in this direction. Similarly, substantial efforts should be made to improve the traditional varieties using minimum disturbance techniques (such as using the Khmer varieties as female parents in the hybridisation programmes, mutation breeding or genetic transformation). Such methods could help ensure the continuity of desired characters of traditional varieties and at the same time improve the yield potential.

Ultimately, there is a clash between the more classic breeding strategies which seek primarily to increase yield and to homogenise production over large areas and those which seek the preservation and enhancement of

varietal diversity on-farm as a laudable goal in itself. In areas of important varietal diversity, such as Cambodia, breeding which is insensitive to local germplasm issues, could contribute as much, if not more, than civil disturbance to the depletion of valuable and often irreplaceable varietal diversity on-farm. Hence the post-war strategies for varietal development will be as important as the post-war strategies for varietal restoration.

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ENDNOTES

1. Within this article, we are using the shorthand 'war' to refer to the extensive period of both civil disruptions and combat extending from the late 1960s to the late 1970s.
2. Photoperiod refers to the number of hours of light and darkness in a day. It is determined by both the latitude and the season. It is an essential factor for the flowering of many plant species. Within species, certain varieties may be more sensitive than others to day length, that is, their performance is more strongly linked to the number of hours of day and night.
3. These varieties were: *Niang Wan, Srao Mok, Laong Tyk Konals, Sraojek, Niang Dey, Niang Son, Srao Sai Pu, Kon Dia, Popiay Thngon, Ongkao Saw, Ongkao Krohom, Kronheng, Niang Pal, Niang Suan, Kua Kronhol*.