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CAMBODIAN FARMERS' DECISIONMAKING IN THE CHOICE OF TRADITIONAL RAINFED LOWLAND RICE VARIETIES

Richard P. Lando and Solieng Mak[1]

ABSTRACT

Many factors influence Cambodian farmers of rainfed lowland rice (RLR) in choosing which traditional varieties they will cultivate. Data collected through interviews with farmers in three Cambodian provinces and through crop cuts taken in their fields during the 1989-90 and 1990-91 wet-season rice harvests helped to identify these factors and clarified their relative influences on the farmers' choices. The factors highlighted are field elevation, varietal maturity, eating quality, and yield potential. Cambodian cultural practices—particularly order of sowing, density of transplanting, and application of fertilizer—also are examined. Composite reasons for farmers' use of varieties are discussed by varietal maturity. Constraints and requirements for farmers' preferred RLR varieties are compared to stated breeding objectives of national breeding and varietal improvement programs.

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CAMBODIAN FARMERS' DECISIONMAKING IN THE CHOICE OF TRADITIONAL RAINFED LOWLAND RICE VARIETIES

Rainfed lowland rice (RLR) was planted in 1.6 million ha in Cambodia in 1989—88% of the total area cultivated in rice. Because RLR is the predominant rice crop, Cambodia depends heavily on it for subsistence. Thus, a national rice breeding program was begun in 1989 in an effort to increase RLR yields. If the program is to achieve that objective, its breeding priorities must take into account the agroecology of RLR (Garrity et al 1986) and the farmers' constraints, needs, and preferences in producing RLR.

The work of Delvert (1961) and Tichit (1981) provides valuable descriptive data concerning Cambodian rice farming, especially in the RLR environment. Both authors noted the diversity of varieties managed by RLR farmers. Delvert said this diversity "without any doubt, diminishes the natural risk of a bad harvest." Tichit said the Cambodian farmer recognizes grain yield and other characteristics of traditional varieties (TVs); and, to minimize risk, he may choose varieties of differing maturities for different field types and hydrological conditions.

Fujisaka (1988) described more precisely the direct influence of field level, water regime, and soil type on farmers' varietal choices. This paper further explores the influence of these three factors, other agronomic considerations, and culinary qualities of varieties on Cambodian RLR farmers' decisions about varietal management.

RESEARCH SITES AND METHODS

The data presented here were gathered as an adjunct to an applied- social-science baseline survey of RLR cultivation in Cambodia. Baseline-survey interviews were conducted in 1989-90 at three sites in Kandal, Takeo, and Kompong Speu provinces, adjacent to Phnom Penh, in which RLR is the principal or exclusive mode of rice production (Table 1). In fact, few economic activities other than RLR production and some palm-sugar production are available to the farmers at the research sites. Crop cuts were taken at these sites and at an additional site in Kandal Province.

Research sites

The two sites chosen in Kandal Province were Dong Kaw District, about 20 km southwest of Phnom Penh on National Route 3, and Kandal Stung District, 5 km further south on the same highway (Fig. 1). The Takeo Province site was Bati District, approximately 30 km south of Phnom Penh. Although some riceland in this district is irrigated, the three villages chosen for sampling have only rainfed ricefields. The Kompong Speu Province site was Samraong Tong District, approximately 35 km west of Phnom Penh.

Table 1. Village clusters where crop-cut sampling and interviewing was conducted.

Province	District	Village cluster
Kandal	Dong Kaw	Proteah Lang
		Pong Tyk
		Cheh Rotes
	Kandal Stung	Tropeang Weng
		Wong Weng
		Thmai
Takeo	Bati	Lompong
		Kondung
		Tropeang Sap
Kompong Speu	Samraong Tong	Samraong Tong
		Tropeang Kong

Fields at the Kandal Province sites slope gently upward away from the main highway and have predominantly light sandy soils. The three lowland villages surveyed in Takeo Province have mainly low and middle fields, with some high fields near a small range of foothills that divides the district. Samraong Tong District in Kompong Speu Province has mainly low and middle fields with predominantly sandy soils.

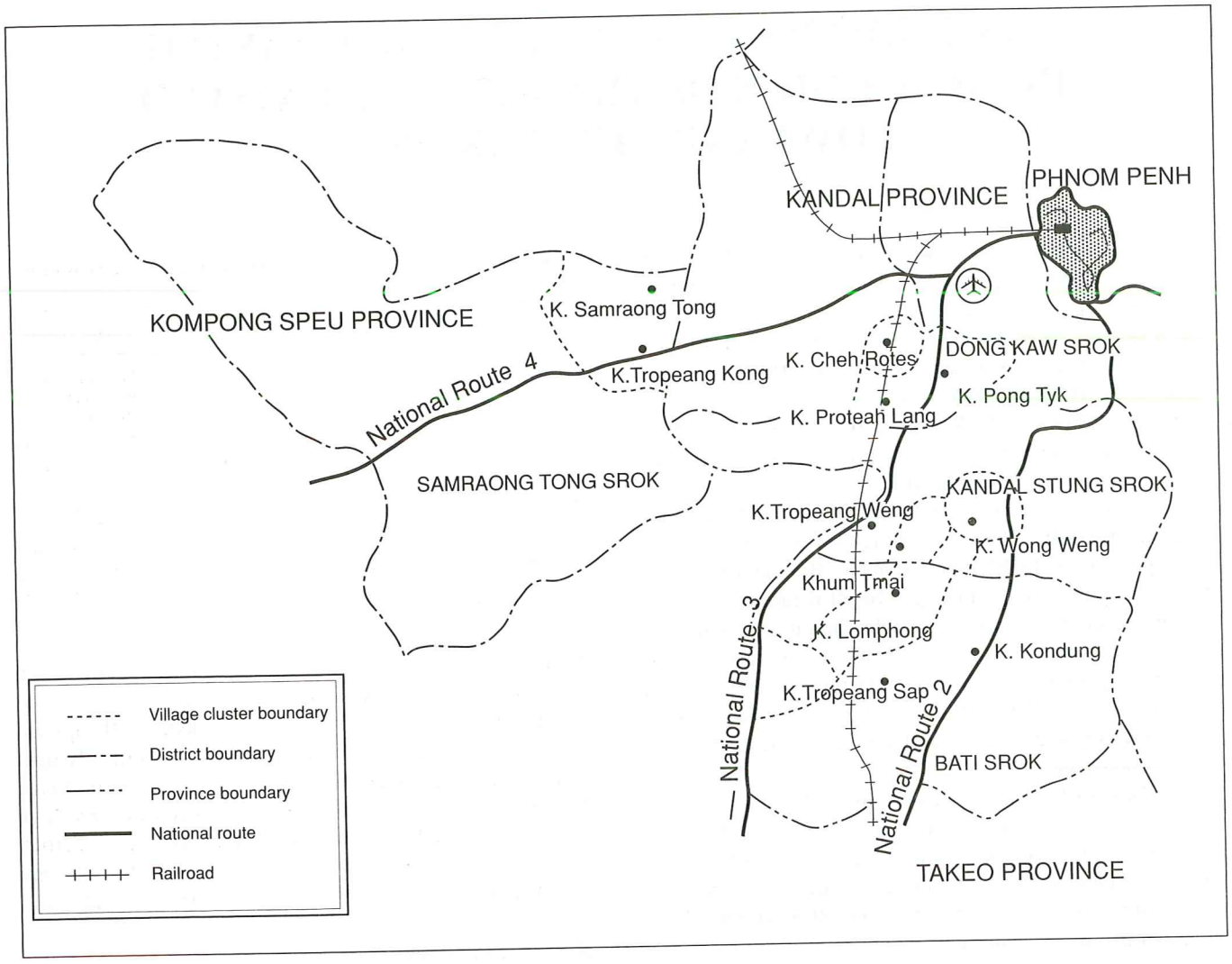
Research methods

Baseline-survey data were collected through interviews with farmers concerning local RLR cropping practices and interviews with village- cluster and district agriculture officials.

The core data of this paper are based on crop cuts taken in farmers' fields during the 1989-90 and 1990-91 wet-season harvests. One objective in making these crop cuts was to calculate yields of local RLR TVs grown in field conditions for comparison to yield data reported by farmers during baseline interviews. Field owners were interviewed when crop cuts were taken to provide additional data on crop-management and input-application practices. The owner of each field in which a crop cut was taken was asked

- what maturity classification he assigned to the variety in that field,
- when he sowed and transplanted the crop in that field,
- how much fertilizer or farmyard manure he applied to that field,
- what eating quality he attributed to that variety, and
- why he planted that variety yearly in that field.

Quantitative and cropping-practice data were elicited using standard, directed questions. Qualitative data about eating quality and reasons for yearly cultivation were elicited



1. Research area.

with nondirected questions to avoid evincing unthought-of responses. Thus, farmers volunteered data in answer to questions such as, "What is your assessment of the eating quality of this rice?" or, "Why do you grow this variety in this field each year?"

Four crop cuts of 4 m^2 were taken for each sample, and the plant population of each cut was counted. The cleaned, threshed rice was weighed; and the mean sample weight at 14% moisture content was used to calculate the yield per hectare. Although yields calculated from crop cuts tend to be higher than farmers' reported yields, the yields calculated from the field data were representative of rice yields at the research sites.

During the 1989-90 harvest, 28 crop cuts were taken: 9 of early-, 4 of medium-, and 15 of late-maturing varieties. Sampling was expanded in both number and area for the 1990-91 harvest—111 crop cuts were taken: 15 of early-, 49 of medium-, and 47 of late-maturing varieties.

FACTORS IN VARIETAL CHOICE

Cambodian RLR farmers base their choices of varieties to plant on a combination of the factors of field elevation, varietal maturity, eating quality, and yield potential.

Field elevation

The elevation of RLR fields and the soil types and water problems associated with elevation are the most important factors governing farmers' choices of varieties (Fujisaka 1988). Delvert (1961) identified only two types of RLR cultivation: "High cultivation," known in Khmer as *sre tuol*, is entirely rainfed and is characterized by light sandy soils. "Low cultivation," *sre chumroeu*, has a more secure water source and predominantly clay soils. These terms are used to describe the distribution of general cultivation types throughout the country. For example, the direct-seeded RLR cultivation practiced in and around Battambang is typical of low cultivation; that practiced in the research areas is more typical of high cultivation.

Fujisaka (1988) compared landform, water regime, and soil type and indicated which TVs encountered during research were suited to each combination. He classified as high fields those that have predominantly sandy soils and maximum standing water of 0-15 cm. He classified as middle fields those that have principally sandy soils but standing water of 10-30 cm. He indicated as low fields those with predominantly sandy, silt, or silt loam soils and maximum standing water of 30-80 cm. Fujisaka also identified a special kind of low field as "*trapaing*" (pond field). Farmers interviewed for this work follow basically the same system of classification as Fujisaka, using the terms *srai leu* for upper fields, *srai kandal* for middle fields, and *srai kraom* for low fields.

High fields in the crop-cut area have predominantly sandy soils. The highest level of standing water that accumulates during the wet season seldom exceeds 20 cm, and the fields are subject to frequent drought. These fields usually are planted with early-maturing varieties that have some drought tolerance and with medium-maturing varieties.

Middle fields included in the survey had principally sandy or sandy loam soils. Farmers said the highest standing water in these fields seldom exceeds 40 cm and middle fields have fewer drought and flooding problems than other field levels. These fields usually are planted with medium-maturing varieties, which are less tolerant of drought and flood than early- or late-maturing varieties but are favored for their eating quality.

Low fields present the rice farmer with several cultivation problems. These fields have principally sandy or clay loam soils with some silt content. The maximum depth of standing water routinely exceeds 30 cm and frequently exceeds 50 cm. In tropeang (pond fields)—depressions or ponds in the ricefields—the maximum depth of standing water may exceed 50-80 cm. In general, low fields are planted with late-maturing varieties that can tolerate this deep water.

The distinctions between high, middle, and low fields are relative and vary from site to site. The ricefields in Samraong Tong District are flat and even, and farmers differentiate only between high and low fields.

The RLR fields surrounding Cambodian villages usually do not slope away in a regular stair-step progression. Different field levels may be distributed in discrete areas around a village or in a patchwork, with a high field immediately adjacent to a low field. Tichit (1981) noted of high-cultivation fields, which are typical of the research sites, "Whatever the form or dimension, each parcel is individually planted without consideration of the level of its neighbor. . .The ricefields appear like a series of basins juxtaposed at different levels."

Government land and production policy since 1979 has dictated the size and distribution of the land allocations of the farmers surveyed and, thus, their need to maintain seed of varieties of differing maturities and agronomic characteristics. From 1982 to 1989, farmers were forced to belong to collective-production units called *krom sammaki* (solidarity groups). Land and the major means of production were owned by the collective. Riceland was farmed jointly by the 10-15 member families, who shared the yield proportionally according to the number of people in each family.

When these units were privatized, village administration officials tended to allocate land of each field level proportionally so that no family received too much undesirable, drought-prone high land or too little desirable land. As a result, a farmer's land allocation is dispersed in as many as 5-8 plots of a few hundred square meters each.

Farmers favor low fields, especially pond fields, because of the generally higher yields obtained in them. Most of their land, however—51% of the land of the farmers included in the baseline survey—comprises high fields, with the remainder in small amounts of middle and low fields. Thus, the farmer must choose varieties that are suited to soil and water conditions at different field levels as well as to culinary preferences. As a result, the farmers surveyed cultivate and maintain seed for as many as four or more RLR varieties of differing maturities and agronomic characteristics.

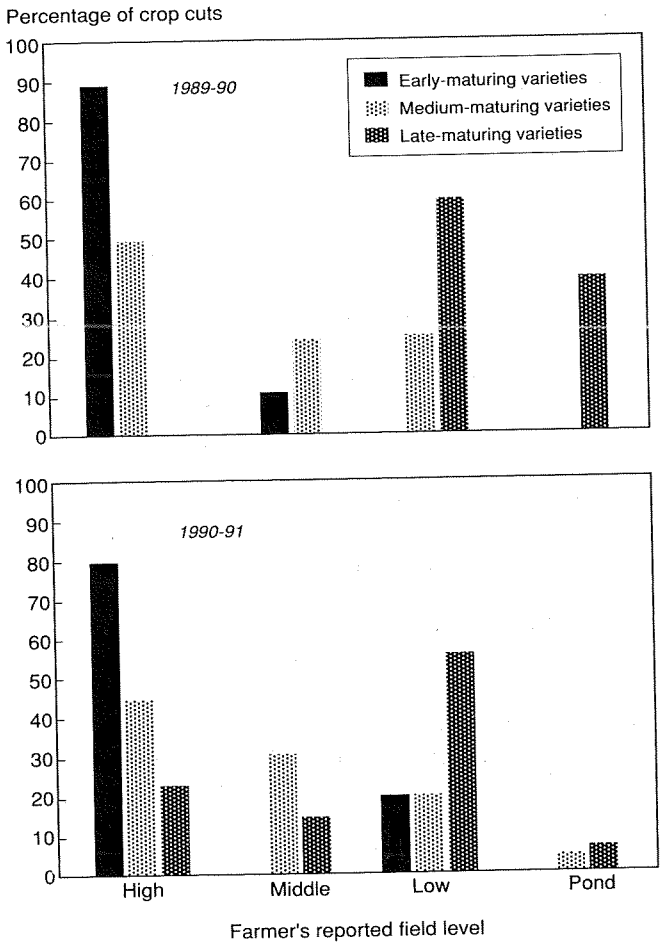
The data from the two seasons of crop cuts largely confirm the observation that early-maturing varieties usually are planted in high fields, medium- and some late-maturing varieties in middle fields, and late-maturing varieties in low fields, despite the relativity of field-level distinction. The 1989-90 data conform more closely to this generalization, although the results may have been biased by the smallness of the sample (Fig. 2). The 1990-91 data are less compatible with the generalization, perhaps because of the drought that occurred during the 1990 wet season. Some farmers had planted a late-maturing variety in their low fields but had to obtain seedlings from neighbors and replant a medium-maturing variety because standing water was insufficient to support late varieties.

Farmers' practice of varying the TVs they plant as a way of coping with environmental stress, as well as optimizing production at differing field levels, underscores the need for varietal diversity in the Cambodian RLR environment.

Varietal maturity

Farmers and rice scientists both consider maturity in classifying RLR varieties; however, their classifications do not always coincide. Rice breeders classify varieties by duration: early-maturing varieties mature in 120 d or less, medium-maturing varieties in 120-150 d, and late-maturing varieties in more than 150 d (R. C. Chaudhary, pers. commun., 1990). Cambodian farmers divide varieties into early-, medium-, and late-maturing categories according to flowering and harvest dates. Rice scientists would classify Cambodian RLR TVs as late-maturing varieties, except for the few photoperiod-insensitive varieties.

French agricultural scientists employ a system of maturity classification that is more like the system used by farmers. Delvert (1961) noted that the Directorate of Agriculture followed an older tradition of four maturity classifications: *riz hatif* (short-duration rice), *riz de mi-saison* (half-seasonal rice),



2. Field level and duration, 1989-90 and 1990-91 crop cuts.

riz de saison (seasonal rice), and *riz tardif* (late rice) (Table 2).

Farmers call photoperiod-sensitive varieties *srao rudow* (seasonal rice) and photoperiod-insensitive varieties *srao bongkaom rudow* (increasing seasonal rice). Srao bongkaom rudow varieties usually are planted during the dry season; but farmers also plant them during the wet season if heavy late rains make it possible for unused fields to be cultivated. Thus, the yield of photoperiod-insensitive varieties increases the stock of grain provided by the usual seasonal varieties.

Farmers divide seasonal-rice varieties into several categories. For example, *srao prang* means "dry-season rice" and *srao wossa*, which includes RLR and deepwater rice, means "wet-season rice."

RLR varieties are further subdivided into *srao sral* (light rice), *srao kandal* (medium rice), and *srao thngon* (heavy rice) (Tables 3 and 4). These categories correspond roughly to the maturity classifications of early, medium, and late. Some photoperiod-insensitive varieties are classified as early maturing, but this description more often refers to photoperiod-sensitive varieties.

If the rains arrive on time and are sufficient, farmers sow early-, medium-, and late-maturing varieties in reverse order to their maturity: late-maturing varieties usually are sown in mid- to late May or early June in low fields that have sufficient standing water; medium-maturing varieties follow in mid-June to early July; and early-maturing varieties are trans-

Table 2. French varietal classifications and percentage of area planted to each for 1967 (Tichit 1981).

Classification	Duration	% of cultivated area
Very early varieties	90 - 120 d	3.1
Early varieties	120 - 150 d	
Half-seasonal varieties	150 - 180 d	12.5
Seasonal varieties	180 - 210 d	43.0
Late varieties	<210 d	19.4
Floating varieties		15.5
Dry-season varieties		6.5

Table 3. Comparison of commonly used terms denoting varietal maturity.

Khmer	French[a]	Maturity	Usual harvest period
Srao sral (light rice)	Riz hatif (short-duration rice)	Early	Late Nov to early Dec
Srao kandal (medium rice)	Riz de mi-saison (half-seasonal rice)	Medium	Mid- to late Dec
	Riz de saison (seasonal rice)		
Srao thngon (heavy rice)	Riz tardif (late rice)	Late	Early to mid-Jan

[a]Delvert (1961).

Table 4. Typical characteristics of traditional varieties suited to the three field levels.

Classification of varieties	Early-maturing varieties	Medium-maturing varieties	Late-maturing varieties
Description	Late Nov-early Dec harvest Drought resistant Subsistence rices with good volume expansion	Mid-late Dec harvest Best cooking quality rices, best sale price	Late Dec-mid-Jan harvest Flood-tolerant varieties, some with elongation ability Medium-good cooking quality with good volume expansion
Field level	High fields Sandy soils Deepest standing water to 20 cm	Middle fields Sandy-sandy loam soils Deepest standing water to 30 cm	Lower fields or pond fields Sandy-sandy loam soils with some silt content Deepest standing water to >50 cm
Field problems	Drought prone and soil subject to heavy compaction after plowing and harrowing	Drought or deep standing water	Intermittent deep standing or stagnant standing water

planted last in the drought-prone high fields in mid-July. The order may vary according to local conditions and preferences. Farmers prefer to transplant seedlings that are 30-40 d old if standing water in the fields is sufficient.

Farmers are at the mercy of the rains, however, for the timing of nursery-bed establishment and transplanting. Delvert (1961) identified two seasons during which rainfall variations can adversely affect the orderly progression of nursery-bed establishment, land preparation, and timely transplanting according to varietal maturity. The first is late May and early June, when a shortage of rainfall can delay nursery-bed establishment and land preparation. The second is the *petite saison seche* (small dry season), a period in July and August when rainfall often ceases or is irregularly distributed, delaying transplanting. Frequently, early rains that allow timely nursery-bed establishment are followed by drought during the middle of the wet season, forcing farmers to transplant seedlings that are 80 d old or older.

Delvert noted that early-maturing varieties called *srao konlas* (half rice) are sown with the first rains and harvested in September to October. These varieties are cultivated principally to replenish depleted granaries before the main harvest. Srao konlas varieties usually are photoperiod insensitive and include both IR varieties and TVs such as *Jantuas Pluk* and *Bai Khai* (Three Months).

Photoperiod-insensitive varieties sometimes are cultivated during other periods in the wet season. Takeo farmers had sown or transplanted early-maturing varieties in September and October of 1989 (harvested in January) to take advantage of unseasonably heavy late rains and increase the aggregate rice harvest.

Srao konlas and *srao prape* are generic Khmer terms for photoperiod-insensitive, early-maturing varieties. Farmers also append the word *konlas* (half) to variety names to indicate that the designated photoperiod-sensitive variety has an earlier harvest date than the eponymous variety.

Kandal farmers cultivate an early-maturing variety, *Phka Sla Konlas*, which is harvested in early December. This cultivar takes its name from a widely cultivated late-maturing cultivar, *Phka Sla*, which is harvested in early to mid-January. Crop cuts were taken in early December in Takeo of another early-maturing variety, *Prambai Kua Konlas*, which derived its name from the variety *Prambai Kua*, classified by farmers as medium or late maturing.

The farmers' early-maturing category includes mostly photoperiod- sensitive varieties that have mid- to late November or early December harvest dates, though some photoperiod-insensitive varieties are included also. Commonly planted early-maturing varieties include *Sombok Ongkrong*, *Lum Ong Ksaich*, and many glutinous varieties (*srao domnawb*).

Farmers cultivate small amounts of glutinous rice yearly. Most glutinous varieties are early maturing, but crop cuts were taken of medium- and late-maturing glutinous cultivars as well. Glutinous rice is the basic ingredient in sweets prepared for weddings, festivals, and especially the Khmer lunar New Year in April. Although it is grown primarily for family consumption, glutinous rice can command a sale price, when it is in demand, of 10-15 riels/kg more than the most favored nonglutinous rice.

Medium-maturing varieties are photoperiod-sensitive and are harvested in mid- to late December or early January. Most of the varieties that are preferred for their eating quality, such as *Phka Khnyai* or *Chma Phrom*, fit into this category. Delvert noted in 1961 that half of the cultivated RLR land in Cambodia was planted with medium-maturing varieties, and these varieties were characteristic of Cambodian rice agriculture.

Late-maturing varieties usually have early to mid-January harvest dates. They are most frequently planted in low fields because most are well adapted to deep standing water and some have moderate elongation ability. Some varieties can tolerate 70 cm of standing water or more and would be classified as deepwater rice by rice scientists (DeDatta 1981).

Derivative varietal names also are common among late-maturing varieties. *Srao laong tyk* is the Khmer term for deepwater rice. The addition of these words to a RLR varietal name indicates that it has a later harvest date than the eponymous variety.

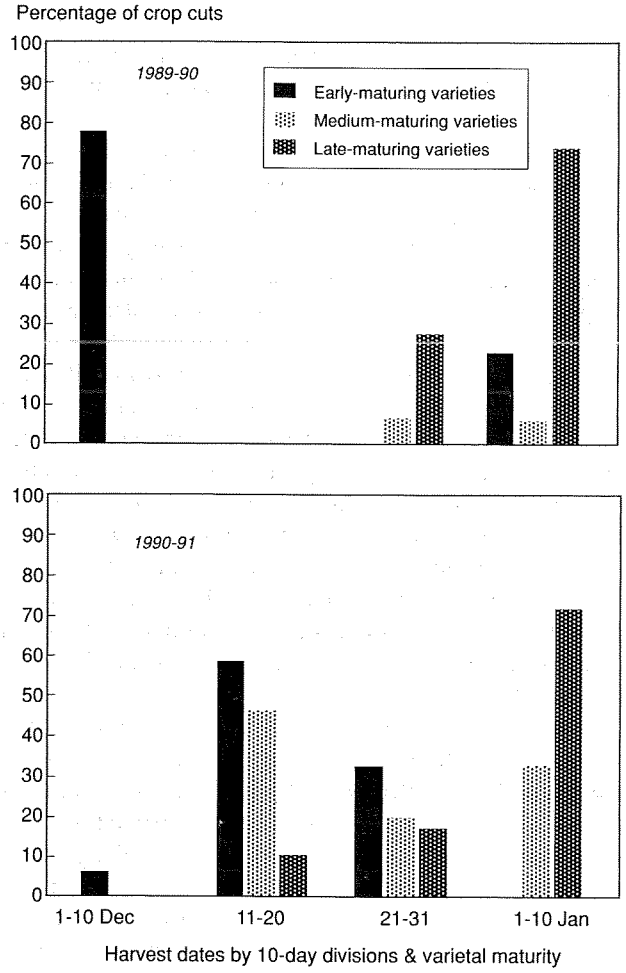
Farmers in Prey Kabas District, adjacent to Bati District in Takeo, cultivate a late-maturing, tall variety with some elongation ability called *Jong Banlas Laong Tyk*, which is harvested in early January. This variety is planted in fields where the standing water does not exceed 1 m and the locally grown floating-rice varieties do not grow well. The name derives from *Jong Banlas*, a medium-maturing RLR cultivar with a mid-December harvest date that is popular in Takeo. Farmers classify *Jong Banlas* as a late-maturing RLR cultivar despite its elongation ability and flood tolerance.

Harvest dates can be fixed more firmly than sowing and transplanting dates because data about sowing and transplanting is strictly anecdotal and harvest dates were established through crop cuts. Nevertheless, harvest data is inconsistent because of variations in classifications and in harvest dates for the same variety.

The ranges of harvest dates of crop cuts for both seasons correspond to the general range of harvest dates described for early-, medium-, and late-maturing varieties, but with a distinct overlap (Fig. 3). Crop cuts of some varieties classified by farmers as medium maturing were taken in mid-December, and those of some varieties classified as early or medium maturing were taken in early January.

Srao Krohom, a medium-maturing variety, is widely cultivated at the Kandal Province sites and is encountered at the Takeo and Kompong Speu sites. Crop-cut dates for this variety ranged from 7-12 Dec in both seasons to as late as 4 Jan in the 1989-90 season. In 1990-91, 19 crop cuts were taken of *Chma Phrom*, a highly favored late-maturing variety that is widely cultivated in Takeo and Kandal. Despite its maturity classification, crop-cut dates ranged from 12 Dec to 5 Jan.

Farmers' classifications of several varieties, elicited during interviews, did not agree. Five farmers in the 1990-91 sample



3. Harvest dates by 10-day divisions and varietal maturity, 1989-90 and 1990-91.

classified *Srao Krohom* as an early-maturing variety, but the remaining 16 classified it as medium maturing. Similarly, 5 farmers of 19 in the same sample classified *Chma Phrom* as a late-maturing variety, but the remainder classified it as medium maturing.

Farmers were even more uncertain in classifying the variety *Prambai Kua*. Fujisaka (1988) identified this variety, transcribed as *Pram Bae Kour*, as a late-maturing variety of 165 days' duration. Eleven crop cuts of *Pambai Kua* were taken during the 1990-91 harvest. Two farmers identified the variety as early maturing, two as late maturing, and the remainder as medium maturing. Actual crop-cut dates similarly ranged from 17-18 Dec to 5 Jan. One crop cut taken on 17- 18 Dec was identified as *Prambai Kua Konlas*—by appending the word *konlas*, the farmer identified it definitely as an early-maturing variety.

This ambiguity can be solved by carefully screening the germplasm of a number of samples of popularly cultivated varieties of the same name. Germplasm collection and screening already were under way in 1990-91. Preliminary results of the screening of 1,258 TVs showed that farmers often subsume varieties with differing harvest dates but similar agronomic characteristics under the same generic varietal name. Samples identified by the common name *Srao Krohom* (Red Rice) ranged in maturity from early to late—and some were true floating- rice varieties rather than RLR cultivars.

Eating quality

Delvert (1961) noted that, while a farmer must assess the agronomic characteristics of a TV rice, he is also sensitive to its culinary qualities. Tichit (1981) noted more specifically, "For his consumption the cultivator shows preference for rice, white or red, which has good volume expansion and which presents qualities of fineness or flavor which are difficult to be discernible to a European palate." Cambodian RLR farmers can easily enumerate these elusive qualities: they prefer varieties that have white, long/slender grains and are aromatic and soft when cooked.

Eating preferences. Owners of fields from which crop cuts were taken said that, generally, medium-maturing varieties had the best eating quality; but their assessments of the eating quality of the varieties sampled, gathered during interviews, were equivocal. The 1990-91 crop-cut data show that respondents rated 57% of the early-maturing varieties sampled as having excellent or good eating quality; 64% of the medium- and 52% of the late-maturing varieties were similarly rated (Table 5). The data concerning early-maturing varieties may have been skewed by the small sample size. Two samples of *Phka Khnyai* (Ginger Flower), a variety farmers classify as early or medium maturing and favor for its eating quality, accounted for the 14% rated as excellent in eating quality.

Volume expansion. In 47 interviews, respondents cited high volume expansion five times as a reason for the yearly planting of the late-maturing varieties sampled. One farmer said simply of a variety with high volume expansion, "A small amount of milled rice feeds a poor man's large family." Varieties with high volume expansion usually are considered to have mediocre eating quality: they are said to have inferior flavor; and, as a result of their expansion, their grains are hard when cooked.

High volume expansion was most often cited as a characteristic of early- and medium-maturing varieties. In the eat-

Table 5. Farmers' assessment of eating quality by varietal maturity, 1989-90 and 1990-91 crop cuts.

Varietal maturity	Eating quality assessment (% of crop cuts)			
	Excellent	Good	Medium	Poor
		1989-90		
Early	11	44	44	
Medium	25	75	0	
Late	0	47	53	
		1990-91		
Early	14	43	43	0
Medium	19	45	36	0
Late	12	40	42	7

ing-quality assessments of the 104 crop cuts of nonglutinous varieties taken in 1990-91, volume expansion was mentioned as a varietal characteristic for 40% of the early-maturing varieties and 81% of the late-maturing varieties but only 27% of the medium-maturing varieties.

Forty-eight crop cuts were taken of *Srao Krohom*, *Chma Prhom*, and *Prambai Kua*. Most farmers classified these three popular varieties as medium maturing and rated them as having good or excellent eating quality. Only 17% of the farmers mentioned volume expansion as a factor in their ratings of the eating quality of these three varieties.

The 1990-91 crop-cut data confirm, to a degree, farmers' general opinion that varieties with high volume expansion have mediocre eating quality. High volume expansion was mentioned as a factor in 18 (42%) of the 43 eating-quality assessments of early- and late-maturing varieties that were rated as medium in eating quality. It was mentioned as a factor in all three assessments of the late-maturing varieties that were rated as poor.

Grain shape. Farmers most often described the grain shape of varieties with good to excellent eating quality as long/slender. Data from laboratory analyses of grain shape and physiochemical characteristics of samples of widely cultivated Cambodian cultivars failed to support farmers' perception. Medium-maturing varieties that were rated as good to excellent in eating quality, such as *Chma Phrom* and *Srao Krohom*, and late-maturing cultivars with medium to poor eating quality, such as *Niang Manh* and *Phka Sla*, were included in samples of 15 varieties analyzed by the International Rice Research Institute. The characteristics examined by the laboratory included grain shape and gel consistency (a measure of cooked grain texture).

Farmers' grain-shape descriptions corresponded to the laboratory's analyses only for the variety *Srao Krohom* (Table 6). At odds with farmers' descriptions, the analyses indicated a medium/bold grain shape for the favored varieties *Chma Phrom* and *Srao Saw*.

Aroma and softness. The 1990-91 crop-cut data also supported farmers' general associations of desirable aroma and soft cooked texture with varieties that have good eating quality and hard cooked texture with varieties that have medium to poor eating quality. Respondents most often mentioned aroma and softness as characteristics of varieties that they rated as having overall good to excellent eating quality, such as the popularly cultivated varieties *Chma Phrom* and *Phka Khnyai*. Similarly, respondents mentioned hard cooked grains as a factor in their eating-quality assessments of 36% of the early-maturing varieties that they rated as medium to poor in eating quality and in those of 30% of the medium- and 42% of the late-maturing varieties.

Farmers' ratings of cooked texture did not correspond to the laboratory's gel consistency analyses (Table 6). Farmers consistently rated the eating quality of the late-maturing variety *Niang Manh* as poor and said its grains were hard when cooked; however, *Niang Manh* received a gel consistency rating of 84, which indicates very soft grains. Two samples of the esteemed variety *Chma Phrom* had gel consistency ratings of only soft and medium-soft.

Correspondence between factors. Eating quality, maturity, and field-level adaptation of RLR varieties correspond directly. Farmers consider early-maturing varieties to be subsistence rice and prefer them for their early harvest, which replenishes depleted granaries, and their high volume expansion. These drought-resistant varieties are best suited to high fields.

Medium-maturing varieties usually have the best eating quality and are best suited to cultivation in some high and most middle fields, where neither drought nor flooding is a problem.

District and village-cluster agriculture officials in the sample areas were asked to list the varieties commonly grown in their areas and to provide examples of varying eating quality (Table 7). *Phka Khnyai* and *Chma Phrom* were the varieties most favored at all three sites. Farmers consider these

Table 6. Comparison of IRRI's ratings of grain quality with farmers' ratings of the same varieties.

Variety	Farmers' described grain shape		Laboratory grain quality analysis		Farmers' described eating quality and cooked grain texture	Laboratory analysis of gel consistency
	Length	Shape	Length	Shape		
Chma Phrom	Short	Slender	Medium	Bold	Best eating quality, soft cooked grains	Medium soft
Chma Phrom (Kandal Province)	Short	Slender	Medium	Bold	Best eating quality, soft cooked grains	Medium
Niang Manh	Short	Bold	Medium	Bold	Poor eating quality, hard cooked grains	Very soft
Phka Sla	Short	Bold	Medium	Bold	Poor eating quality, hard cooked grains	Medium soft
Prambai Kua	Medium	Bold	Medium	Bold	Medium eating quality, hard cooked grains	Medium
Srao Krohom	Long	Slender	Long	Slender	Medium-good eating quality, hard cooked grains	Very soft
Srao Saw	Medium	Slender	Medium	Bold	Medium-good eating quality, hard cooked grains	Medium soft

Table 7. Agriculture officials' mention of popular varieties and their eating qualities, by province.

	Kandal	Takeo	Kompong Speu
Variety			
Early-maturing	Sombok Ongkrong Krojoh Jap Domnawb Smach Domnawb Tong Lahong Domnawb Chiam Angtong	Sombok Ongkrong Aruth Jontuas Pluk Srao Krohom	Lum ong Ksaich Sek yual Jumriab pdaw
Medium-maturing	Srao Krohom Chma Phrom Dong La-ut	Phka Khnyai Kung Kombot Chma Phrom Phka Tian Tong Mlu Prambai Kua Niang Manh	Chma La-ut Chma Phrom Niang Saw
Late-maturing	Chma Jongkaom Phka Sla Kung Pluk Tombing Pui Phka Mie	Pkha Sla Muai Roi Jai	Phnia Phrom Sro Krohom Kung Ka
Eating quality assessment			
Excellent	Chma Phrom Phka Khnyai	Phka Khnyai	Chma Phrom Phnia Phrom
Good	Niang Saw Srao Krohom Kung Kombot	Tong Mlu Chma Phrom	Srao Saw
Poor	Phka Sla	Kung Kombot	Varieties with short/bold grains

widely cultivated medium- and late- maturing varieties to be the exemplars of eating quality. Delvert (1961) noted that "*Chmar Proum*" was renowned for its quality.

Farmers said during interviews that more late- than early- and medium-maturing varieties have undesirable short/bold grains. Some late-maturing varieties are thought to have better eating quality than most medium-maturing varieties, however, such as the variety *Kung Pluk* in Kandal. Late-maturing varieties' tolerance of the deep standing water in low and pond fields is their primary advantage.

A survey of rice breeders conducted by Mackill (1986) revealed that Southeast Asian breeders prefer varieties that have intermediate amylose content. The cooked grains of such varieties are soft and separate; that is, they have the texture that Cambodian farmers prefer. All 15 of the varieties analyzed by the International Rice Research Institute for this study had intermediate amylose content, and none had higher than 28% amylose. Similarly, 78% of the breeders responding to Mackill's survey preferred medium- or long-grain varieties, and 74% preferred slender grain shape, as do Cambodian farmers.

The lack of correspondence between farmers' ratings of grain shape and texture and results of laboratory analyses highlights the problems that breeders face in developing varieties that meet farmers' preferences for the subjective characteristics of eating quality. Farmers' tendency to apply generic varietal names to a range of similar varieties has been noted. Perhaps the two samples of *Chma Phrom* that were tested were not the most preferred varieties of that range and, therefore, their gel consistency ratings were less favorable than those of the best *Chma Phrom* varieties would have been.

The fact that *Niang Manh* received a gel consistency rating of very soft when farmers say its cooked grains are hard may call into question the relevance of laboratory quality testing for Cambodian RLR varieties. It is equally possible that farmers' preconceptions about the eating quality of varieties of different maturities may prejudice their judgments.

Yield potential

Yield potential is a major factor in farmers' choices of varieties to plant, although equal consideration is given to survival characteristics for early- and late-maturing varieties. Although sample size differed between the two seasons studied, the trends in average yields were similar (Fig. 4). The average yield of most crop cuts of early-maturing varieties in both seasons was 1.25-1.5 t/ha. The graphed average yields of crop cuts of both medium- and late-maturing varieties peaked in the 1.5-1.75 t/ha category, but late-maturing varieties had consistently higher average yields.

Overall average yields for crop cuts of each varietal maturity did not differ significantly, and average yields were consistent between seasons. The overall average yields of early-maturing varieties were 1.68 t/ha for 1989-90 and 1.77 t/ha for 1990-91. Overall average yields of medium-maturing varieties were similarly close: 1.89 t/ha for 1989-90 and 1.67 t/ha for 1990-91. Overall average yields of late-maturing varieties were marginally the highest: 1.87 t/ha for 1989-90 and 1.84 t/ha for 1990-91.

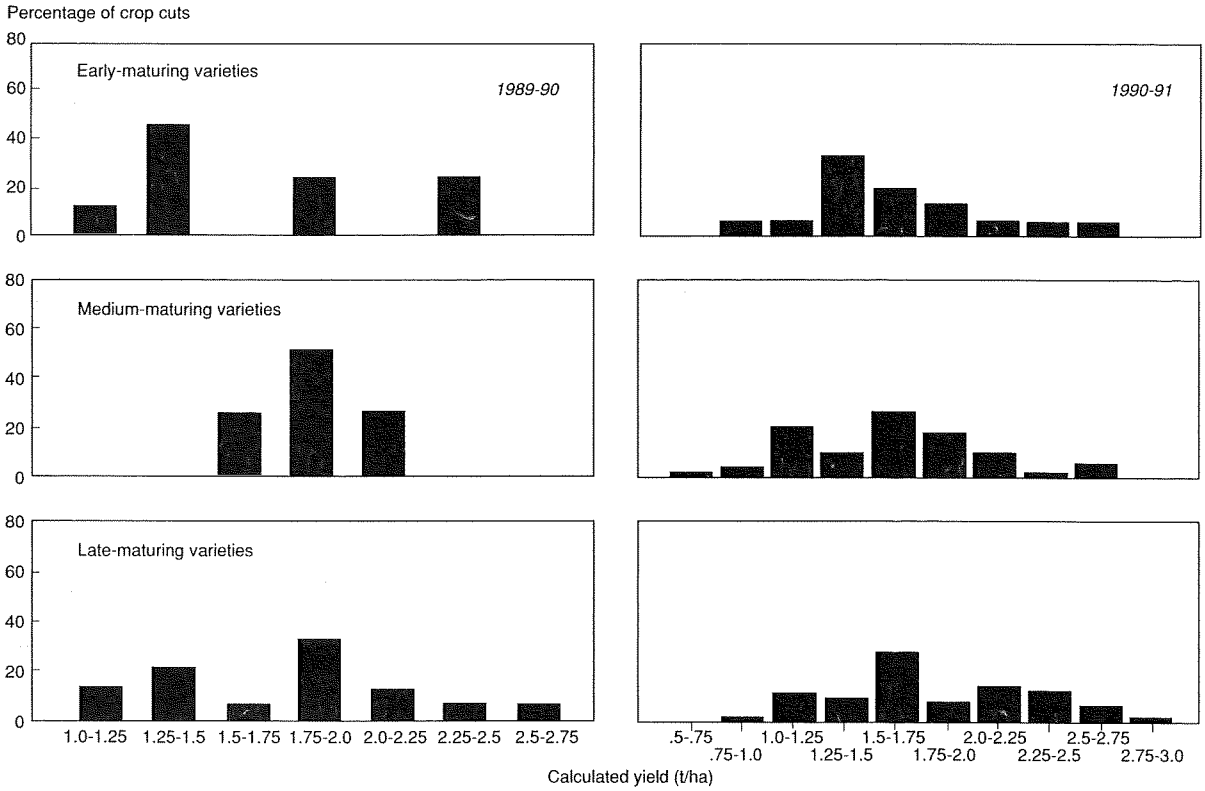
The higher average yields of medium- and late-maturing varieties account in part for farmers' preference for medium and low fields to which these varieties are best suited. However, more than 50% of the land allocations of the baseline-survey farmers were high fields. Therefore, farmers are forced to plant the lower yielding, early-maturing varieties that are best suited to these drought-prone fields.

CULTURAL PRACTICES

Interview data provided by field owners during the conduct of the crop cuts provide a clear picture of farmers' crop-management practices in Cambodia.

Order of sowing

The 1990-91 data set reflects only in part the posited orderly progression of sowing late-, then medium-, and finally early-maturing varieties (Fig. 5). The sowing of medium- and late-maturing varieties peaked in mid- to late May, but most varieties of all maturities were sown first in early June and second in early July. The range of sowing dates after early July shows greater adherence to the posited order. The percentages of medium- and late-maturing varieties sown in this period tapered off, and that of early-maturing varieties increased.



4. Average yields by maturity, 1989-90 and 1990-91 crop cuts.

The 1989-90 data set conforms more closely to the posited order than the 1990-91 set.

The distribution of planting dates for both seasons (Fig. 6) reflect the practice of transplanting according to the availability of sufficient standing water more than transplanting serially according to varietal maturity.

The three environmental stresses that farmers cited most frequently in interviews were general drought, drought after transplanting, and drought that delayed transplanting (Table 8). Most medium- and late-maturing varieties were transplanted from early August to early September. Most early varieties were transplanted in either early August or mid-September. Thus, farmers said that sporadic rains in August and lack of substantial rainfall until mid- to late September seriously delayed transplanting.

Density of transplanting

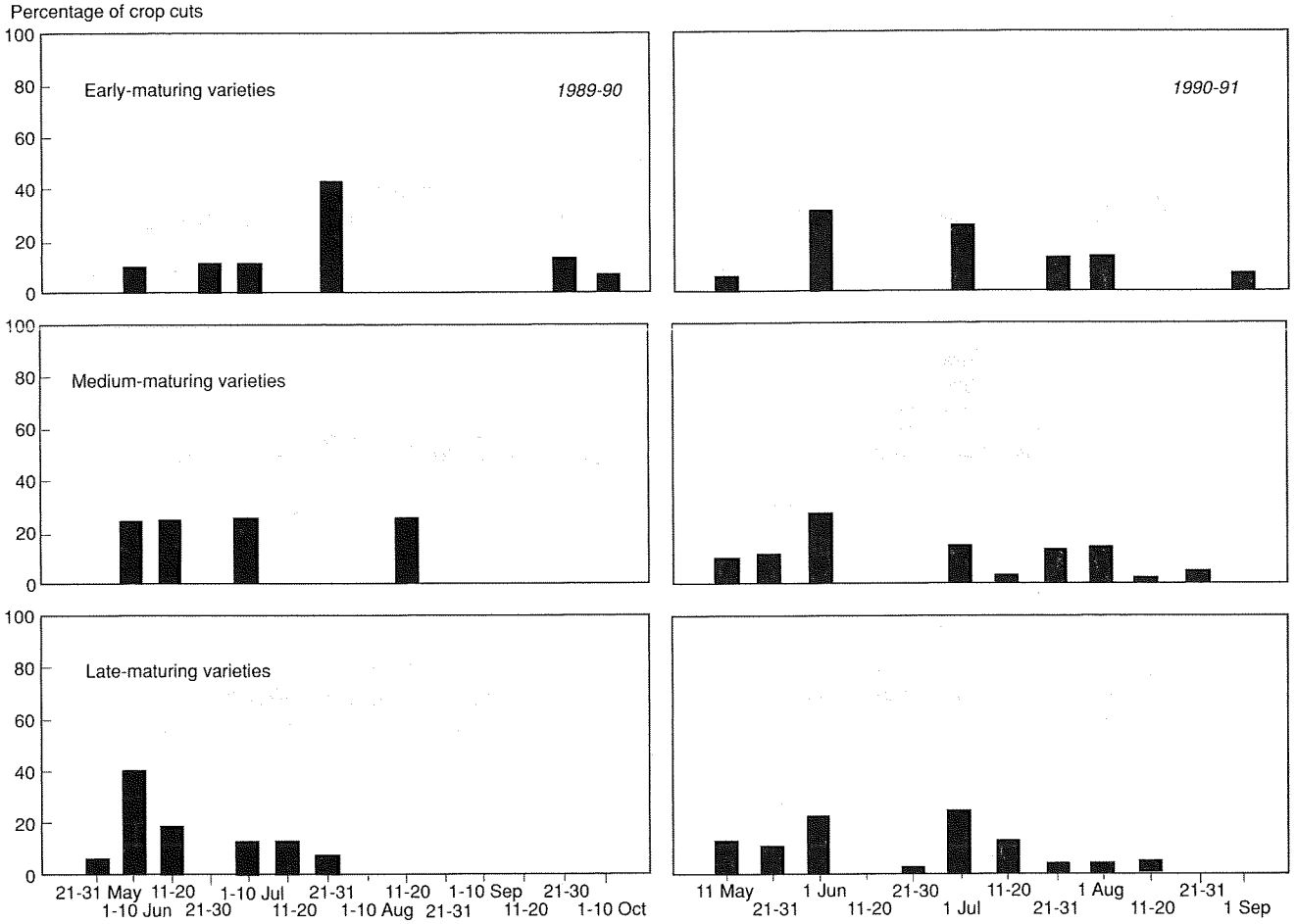
Changing the density at which farmers customarily transplant seedlings may be a simple way to increase the productivity of Cambodian RLR.

The data collected during this study show that Cambodian RLR farmers tend to transplant varieties of all maturities within a narrow range of number of hills/m^2 (Fig. 7). Most of the 1990-91 crop cuts of all varietal maturities were transplanted with 20-25 hills/m^2. This density approaches the 25 hills/m^2 achieved with row transplanting at 20 × 20 cm between rows and hills, as is recommended for RLR TVs.

Significantly fewer crop cuts were observed with plant populations of 26-30 hills/m^2 or more. All field owners who transplanted with more than 30 hills/m^2 reported that they transplanted during extreme drought: they compensated by transplanting with up to 40 hills/m^2. The smaller 1989-90 sample conformed to this trend: most of the crop cuts were transplanted with 20-25 hills/m^2.

The data also show that plant population tends to decrease according to varietal maturity from early to late. Most of the 1990-91 crop cuts of early-maturing varieties had plant populations of 26-30 or 20-25 hills/m^2, and greater percentages of the crop cuts of medium- and late- than of early-maturing varieties were transplanted with plant populations of 15-19 hills/m^2. The trend is clearer in the 1989-90 sample, with 47% of the crop cuts of late-maturing varieties having plant populations of 15-19 hills/m^2 and 27% having populations of only 10-14 hills/m^2. Differential spacing based on varietal maturity was consistent in all three sample areas.

Farmers' practice of varying the plant population according to varietal maturity may reflect intimate knowledge of the soil and water conditions of their various fields and the agronomic potential of the varieties they plant yearly. Close spacing is necessary for the shorter, early-maturing varieties planted in high fields (where drought is common and infertile sandy soils predominate) to ensure an adequate number of productive panicles per square meter. Older farmers said they transplanted early-maturing varieties with higher plant populations than varieties of other maturities, as a rule of thumb, and increased plant population in response to drought in any field.



5. Sowing dates by 10-day divisions and varietal maturity, 1989-90 and 1990-91.

Table 8. Frequency of environmental stress, 1990-91 wet-season crop, by varietal maturity.[a]

Varietal maturity	None	Drought (general)	Drought after	Overage seedlings/ delayed transplanting	Transplanted dry	Excess standing	Drought in nursery	Two reasons in
Early	9	2	2	2	1	0	2	3
Medium	17	18	7	8	4	4	1	10
Late	27	10	8	1	1	1	1	2
Total	53	30	17	11	6	5	4	15
% of responses	48	27	15	10	5	5	4	

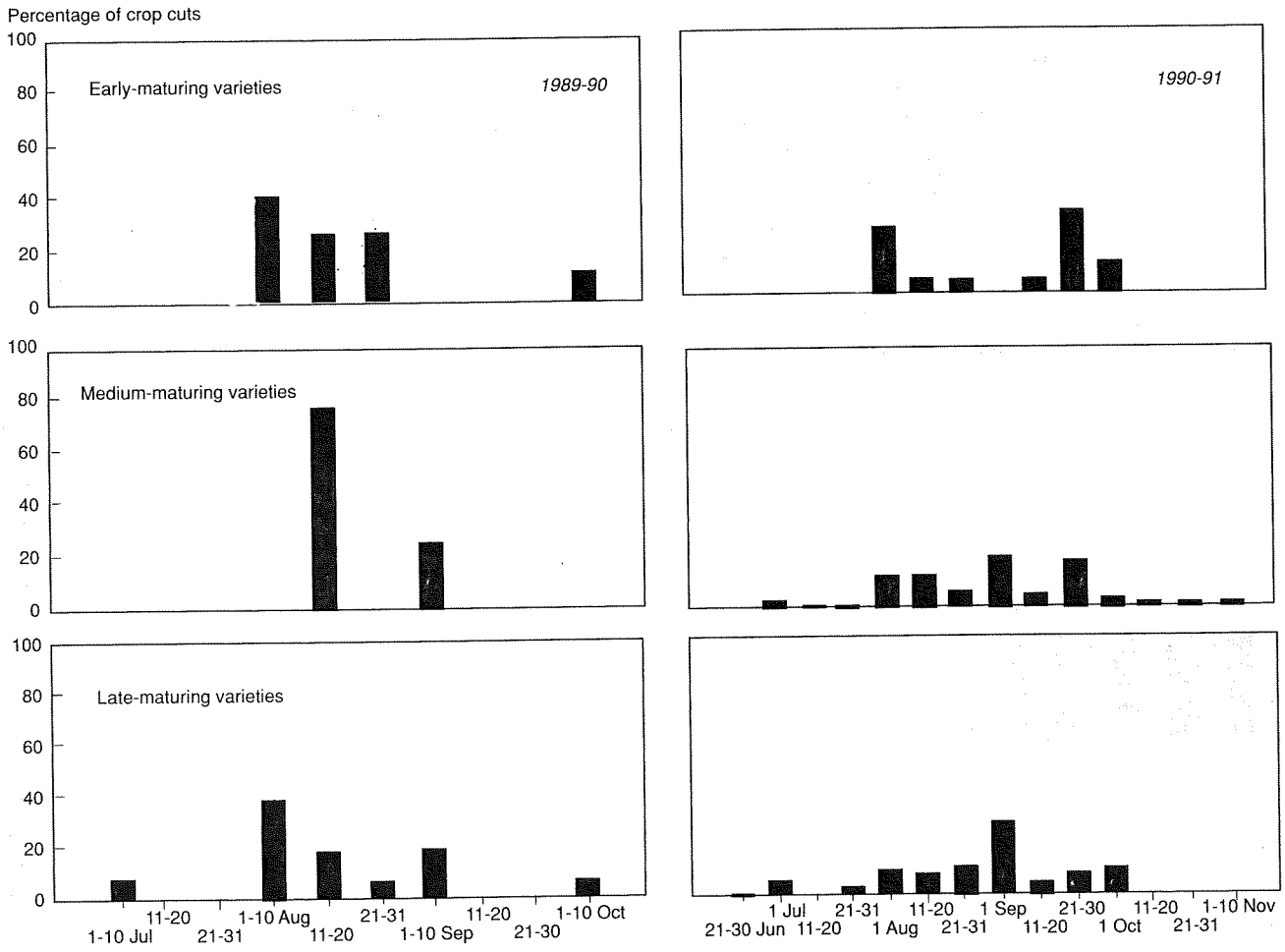
[a]Questions concerning environmental stress were nondirected; farmers volunteered the information. Percentages are based on the total number of times the factor was mentioned in 111 interviews, not on total number of responses.

The especially sparse plant population of 10-15 hills/m^2 was seen only in pond fields, which are fertile and frequently have more than 50 cm of standing water. Many of the late-maturing varieties planted in pond fields have slight elongation ability, which helps them survive in deep water, and are lodging resistant at heights up to 1.8 m. An adequate plant population and closure of the plant canopy is achieved with these varieties in pond fields, even with such wide transplanting spacing.

Application of fertilizer

Owners of crop-cut fields were interviewed about the amounts of chemical fertilizer and farmyard manure (FYM) they used and the times at which they applied these inputs (Table 9). The responses differed significantly from responses to similar questions asked during RLR baseline-survey interviews with 45 farmers of the same districts concerning the 1989-90 crop.

Baseline-survey data for 1989-90 showed that only 6 farmers (13% of the total sample) applied no fertilizer or FYM



6. Transplanting dates by 10-day divisions and varietal maturity, 1989-90 and 1990-91.

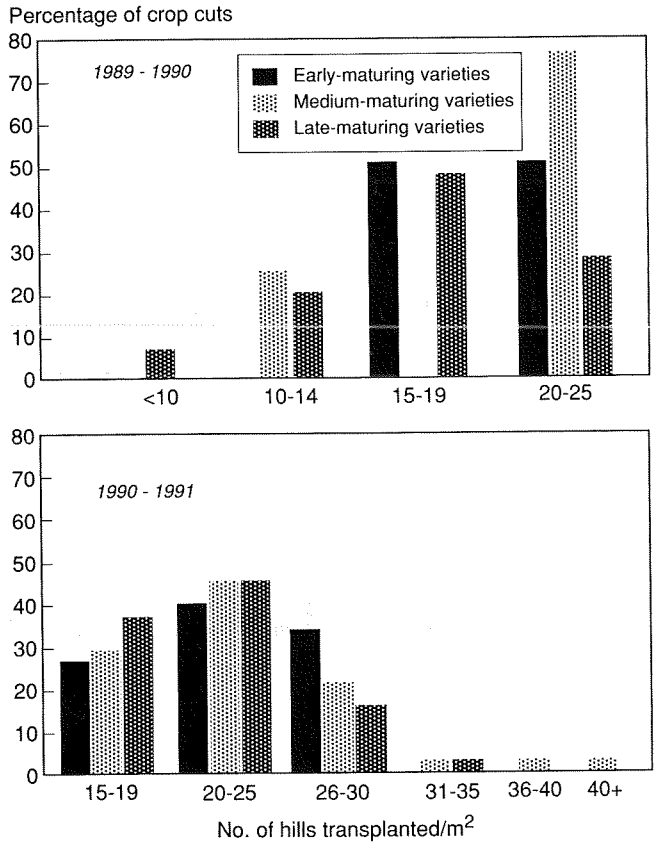
to their crops, and 38 (87%) applied some fertilizer or FYM. Baseline-survey farmers applied an average of 13.6 cartloads of FYM (3.8 t) to nursery beds and 6.7 cartloads (1.8 t) to transplanted fields. Nineteen farmers (42%) of the same sample applied an average of 43 kg ammophos fertilizer/ha (5.3 kg N/ha, 20 kg P/ha), and 28 (62%) applied 40 kg urea/ha (28 kg N/ha).

Field owners interviewed during both crop-cut seasons reported applying less fertilizer and FYM to their crops than did baseline-survey participants, and a greater percentage said they applied none. Nine field owners (31%) of the 1989-90 sample and 21 (23%) of the 1990-91 sample applied no fertilizer or FYM to their crops. Only 16 farmers (57%) of the 1989-90 sample and 63 (57%) of the 1990-91 sample reported applying any manure to their nursery beds or transplanted crops. The average amount applied to nursery beds was 4 cartloads (1.1 t) in 1989-90 and 5 cartloads (1.4 t) in 1990-91.

For both crop-cut samples, the number of field owners who applied chemical fertilizer, alone or with FYM, and the amounts they applied also were low in comparison to the baseline-survey data. Six field owners (21%) of the 1989-90 sample applied some urea to their crops, averaging 17.7 kg N/ha. Only 10 field owners (10%) of the 1990-91 sample reported applying any chemical fertilizer, alone or in combination with FYM. Those who used urea during that season applied an average of 19.8 kg N/ha; those who used ammophos fertilizer applied an average of 19.8 kg N/ha, 11.5 kg P/ha.

The government could not provide fertilizer to the farmers at subsidized prices during the 1990 wet season. Since the farmers can afford only subsidized fertilizer, its unavailability may account for the low reported use for the second crop-cut season.

Sampling factors and environmental stress may help to explain further the discrepancies in reported fertilizer and FYM use between the baseline-survey data and the crop-cut data. Baseline-survey farmers were asked to report the amounts of fertilizer and FYM they applied to their entire crops and land allocations. Field owners in the crop-cut samples were asked for the same data concerning only the fields in which the crop cuts were taken. The percentages of the farmers' total land allocations represented by these fields was not ascertained. Thus, the farmers may have applied additional



7. Observed plant populations in fields, 1989-90 and 1990-91 crop cuts.

Table 9. Frequency of reported fertilizer application by varietal maturity, 1989-90 and 1990-91 crop cuts.[a]

Varietal maturity	No fertilizer	FYM[b] to nursery beds	FYM to fields	Chemical fertilizer only	Chemical fertilizer and FYM
		1989-90			
Early	2	6	0	0	1
	(22)	(67)	(0)	(0)	(11)
Medium	1	2	0	0	1
	(25)	(50)	(0)	(0)	(q5)
Late	3	8	0	3	1
	(20)	(53)	(0)	(20)	(7)
Total	6	16	0	3	3
	(21)	(57)	(0)	(11)	(11)
		1990-91			
Early	6	4	4	1	0
	(40)	(27)	(27)	(7)	(0)
Medium	14	15	17	2	1
	(29)	(31)	(35)	(4)	(2)
Late	14	9	17	3	4
	(30)	(19)	(36)	(6)	(9)
Total	34	28	38	6	5
	(31)	(25)	(34)	(5)	(5)

[a]Figures in parentheses are percentages of sample. [b]FYM = farmyard manure.

fertilizer to fields not included in the survey.

Furthermore, Cambodian RLR farmers avoid using expensive chemical fertilizer or limited supplies of FYM in times of environmental stress. The 1990 wet-season drought occurred precisely at the time that fertilizer or FYM should have been applied; thus, farmers may have applied less fertilizer than they would have if the drought had not occurred.

FARMERS' REASONS FOR VARIETAL CHOICE

The Cambodian RLR farmer considers the entire range of factors discussed here—soil and water conditions in the field, varietal maturity, and eating quality—in selecting the appropriate TV for each plot in his land allocation.

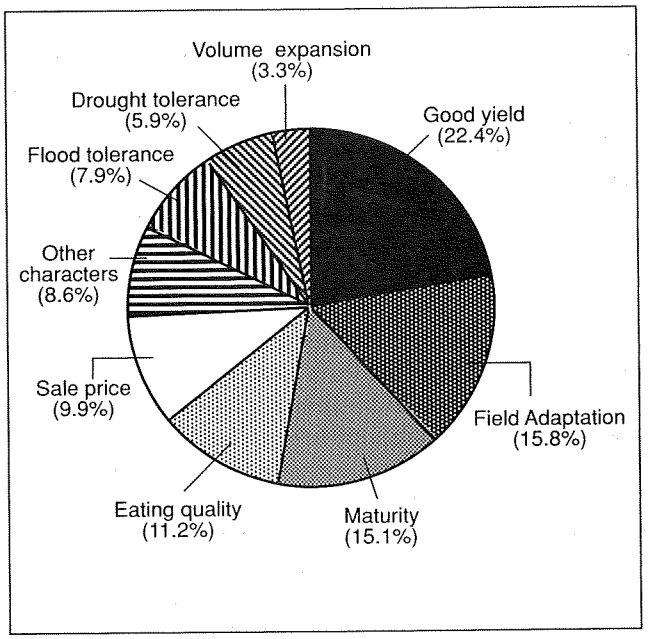
Of the reasons farmers offered for yearly cultivation of varieties, high yield was cited most frequently for all varieties sampled in the 1990-91 crop cuts (Fig. 8). However, when the data are broken out by varietal maturity, a different picture emerges (Figs. 9-11). High yield was mentioned most frequently only for medium-maturing varieties. Farmers cited field adaptation and maturity as frequently as yield in their reasons for the yearly cultivation of early-maturing varieties. Flood tolerance, the key survival characteristic for late- maturing varieties, was mentioned as often as yield for those varieties. Despite farmers' perception that medium-maturing varieties are high yielding, the calculated mean and overall yields of late- maturing varieties were marginally higher than those of medium- maturing varieties.

Among the reasons volunteered for annual cultivation, field adaptation was mentioned nearly as often as yield for all varietal maturities. Farmers said simply that the variety sampled was suited to the hydrological conditions of the plot and did not allude to problems of drought or deep standing water specifically. Field adaptation was cited more frequently for early- and late-maturing varieties than for medium-maturing varieties.

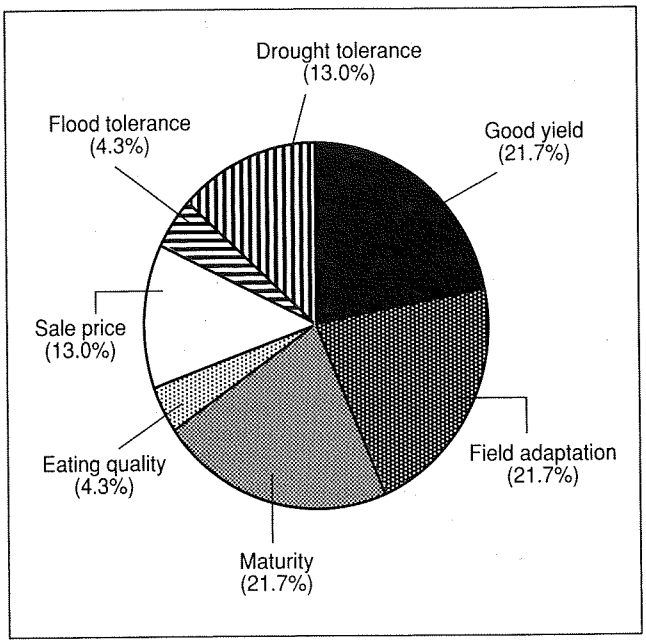
Among the survival characteristics that were mentioned, drought and flood tolerance were cited most frequently for early- and late-maturing varieties. While drought tolerance was prominent among the composite reasons for cultivating early-maturing varieties, farmers cited flood tolerance as often as high yield among their reasons for cultivating late-maturing varieties. Neither drought nor flood tolerance was mentioned frequently for medium-maturing varieties.

Other agronomic characteristics were offered as reasons for annual cultivation only for medium- and late-maturing varieties. For medium-maturing varieties, farmers cited characteristics associated with yield, such as panicle size and number of seeds per panicle or milling recovery. For late-maturing varieties, reasons usually concerned plant characteristics, such as lodging resistance. Two farmers in Takeo said they had switched from the variety *Kung Pluk*, favored for its eating quality but susceptible to lodging, to *Kul* or *Kung Kombot*, which are more resistant to lodging.

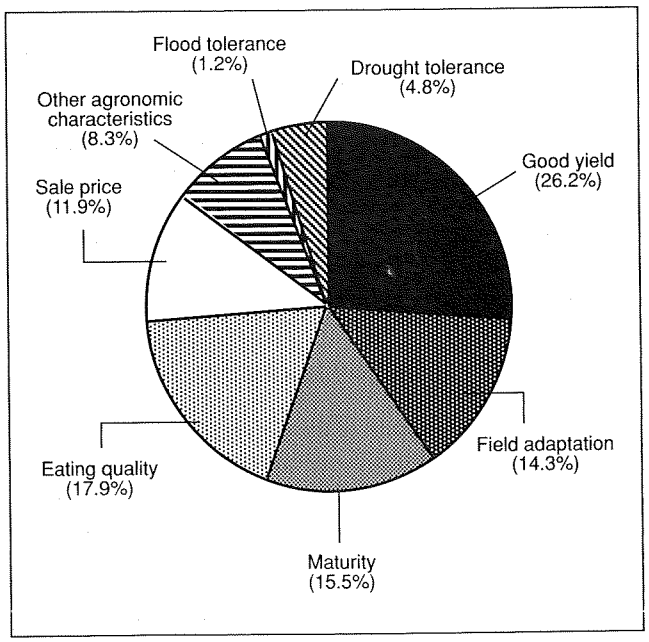
The generalizations that medium-maturing varieties have the best eating quality and sale price and early- and late-maturing varieties are favored for their volume expansion are lent credence by farmers' assessments of eating quality and



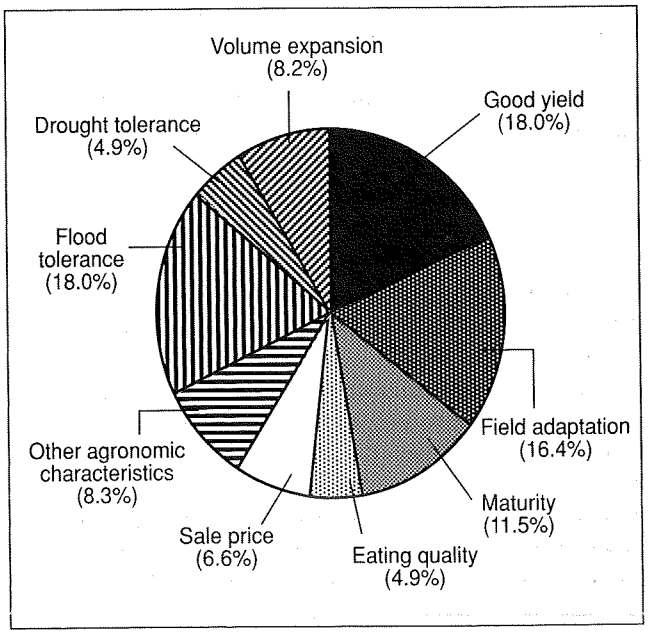
8. Farmers' reasons for choosing varieties, 1990-91 crop cuts.



9. Farmers' reasons for selecting early-maturing varieties, 1990-91 crop cuts.



10. Farmers' reasons for selecting medium-maturing varieties, 1990-91 crop cuts.



11. Farmers' reasons for selecting late-maturing varieties, 1990-91 crop cuts.

their reasons for planting the sampled varieties yearly. Only high yield was mentioned more often than eating quality as a reason for choosing medium-maturing varieties. High volume expansion was cited more often than eating quality in general for late-maturing varieties. High sale price was prominent among the reasons cited for growing medium-maturing varieties each year: the premium medium-maturing varieties command the highest sale price and are sold by varietal name in the Phnom Penh markets. High sale price was mentioned frequently for early-maturing varieties, also, because farmers' and traders' stocks of rice are depleted at the time that early-maturing rice is harvested and, therefore, rice is in high demand.

SUMMARY AND CONCLUSIONS

The range of farmers' expressed reasons for yearly cultivation of the varieties sampled in crop cuts reflects the complexity

Table 10. Characteristics of traditional Cambodian RLR varieties and suggested breeding objectives for varietal improvement.

Varietal maturity	Existing characteristics	Breeding objectives
Early	Tall, lodging-susceptible	Irrigated variety plant type, taller
	Some varieties photoperiod-sensitive	Photoperiod-insensitive, 100-120 d duration
	Drought-resistant	Drought-resistant
	Low-yielding	Increased yield
Medium	Tall, lodging-susceptible	Strong plant type, 140 cm plant height
	Photoperiod-sensitive	Photoperiod-insensitive or weakly sensitive, 120-150 d duration
	Superior eating quality	Superior eating quality
	Low-yielding	Increased yield
Late	Tall to very tall	Strong plant type, 140 cm plant height
	Strongly photoperiod-sensitive	Strongly photoperiod-sensitive, 150 d duration or greater
	Flood tolerant due to elongation capacity	Submergence tolerant due to elongation capacity
	Low-yielding	Increased yield

and difficulty of rice cultivation in the RLR environment. Farmers must consider survival characteristics, such as drought and flood tolerance, equally with yield and culinary preference as they choose appropriate early- and late-maturing varieties for cultivation in their high and low fields. They can give more weight to the factors of yield and sale price in choosing medium-maturing varieties because the fields to which these varieties are best suited are less prone to environmental stress.

The breeding objectives for RLR varietal improvement of Cambodia's national rice production intensification program should take into account farmers' priorities in choosing varieties for cultivation (Table 10). Unless new varieties are introduced through a well-formulated extension and training program, farmers will be reluctant to adopt them or will experience severe yield losses in growing them. If photoperiod-insensitive or weakly sensitive early- and medium-maturing varieties are introduced, farmers will have to alter their sowing strategies radically. They will have to be taught to manage photoperiod-insensitive varieties in RLR fields through careful on-farm trials and a strong extension and training program. It may be wise to introduce early-maturing, photoperiod-sensitive varieties that flower in late October. The strong photoperiod sensitivity of currently cultivated early- and medium-maturing varieties helps farmers to compensate for environmental stress: if standing water is insufficient when seedlings are the optimum age for transplanting, farmers can delay transplanting until conditions improve because the seedlings still can be used at 60 d old or older.

If late-maturing cultivars are introduced, extension workers must clearly explain to farmers that submergence tolerance lets these varieties survive intermittently deep standing water and must show them how this characteristic differs from the elongation ability of existing tall, late-maturing cultivars. Breeders need to know that submergence tolerance may be an inappropriate characteristic for varieties that farmers must plant in fields that have stagnant, deep standing water for 2 mo or more.

The data presented here demonstrate that Cambodian RLR farmers understand the complexity and risks of the RLR environment and consider them when choosing varieties to plant. The farmers' varied reasons for the annual cultivation of locally favored varieties are rational, and the large complex of available varieties is needed to meet the demands of the Cambodian RLR environment. Farmers weigh the relevant survival characteristics of early-, medium-, and late- maturing varieties against desirable eating quality in deciding how best to provide enough rice to fill their granaries. Farmers' strategies in varietal management as shown here seem to belie Tichit's (1981) assertion that Cambodian RLR farmers "even occasionally practice a varietal rotation without any real advantage."

Rice breeders have their own priorities for improving the plant type, yield potential, and survival characteristics of RLR varieties to intensify rice production in Cambodia. They, and other agricultural scientists working to change and improve rice varieties and farming practices in Cambodia, must understand how farmers choose varieties and manage crops if their efforts are to be effective. Whether new varieties are introduced or existing cultivars are more widely distributed, the focus of these efforts must be to benefit farmers.

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REFERENCES CITED

DeDatta S K (1981) Principles and practices of rice cultivation. John Wiley & Sons, New York.

Delvert J (1961) Le Paysan Cambodgien. Mouton Co. La Haye, Paris.

Fujisaka S (1988) Rice agroecosystems, farmer management, and

social organization in Kampuchea: a preliminary assessment and research recommendations. IRRI Res. Pap. Ser. 136 p.

Garrity D P, Oldeman L R, Morris R A, Lenka D (1986) Rainfed lowland rice ecosystems: characterization and distribution. Pages 3-23 in Progress in rainfed lowland rice. International Rice Research Institute. P.O. Box 933, Manila, Philippines.

Mackill D J (1986) Varietal improvement for rainfed lowland rice in South and Southeast Asia: results of a survey. Pages 115-145 in Progress in rainfed lowland rice. International Rice Research Institute, P.O. Box 933, Manila, Philippines.

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