

Management of Litchi Genetic Resources in Réunion

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A litchi germplasm repository was set up in Réunion to diversify litchi crops and provide a basis for breeding programmes. Fruit and floral descriptors were determined to characterize litchi varieties.
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introduction

Litchis (*Litchi chinensis* Sonn.) were first brought to Réunion (Indian Ocean, 21°20' latitude S, 55°25' longitude E) by Pierre POIVRE in 1779. They were cropped on the island throughout the 19th century; there are now more than 1 000 ha of litchi orchards, making it the most widely grown fruit crop in Réunion.

These orchards are mainly cropped with cvs Kwai-Mi and Tai-So, which produce excellent-flavoured litchis that are suitable for both domestic and export markets. There are also some so-called "cv Litchi Toupie" trees that produce a spinning-top shaped fruit with an aborted pit.

The shortness of the production period could be explained by the lack of diversity in litchis of Réunion, mainly due to the conventional use of the air marcotting technique for propagating this fruit. Litchis are harvested from late November to mid-January because the climate differs on the windward and leeward sides of the island. In addition, there are several drawbacks concerning cv Kwai-Mi, i.e. the fruit does not stand up well to cyclonic winds, it shows marked biennial bearing and high vigour.

CIRAD-FLHOR has set up a litchi germplasm repository at different locations in Réunion with the aim of broadening the varietal base and minimizing drawbacks that arise as a result of monocropping

cv Kwai-Mi. The following features are being sought:

- lengthening the production period,
- improving resistance to cyclonic winds,
- reducing biennial bearing,
- increasing fruit quality and storage potential.

This repository provides a litchi pool that is utilized for varietal breeding programmes whose results have a direct impact in the field. Varietal descriptions are also under way with this plant material.

setting up the litchi repository

accession origins

The first mass introduction of litchi varieties took place in 1985 with 26 different varieties that had been imported from Australia, India and the Seychelles.

Other varieties were introduced after being collected in various countries, i.e. Bali, Hawaii, Mauritius, New Caledonia and Thailand.

These litchi varieties were generally introduced in the form of suckers and scions, and less commonly as seeds.

Eleven different varieties producing fruit that differ from that of cv Kwai-Mi were obtained in surveys conducted in Réunion (NORMAND, 1990a).

Table 1 provides a list of the different varieties and their origins.

locations of litchi introductions

The first litchi introductions in Réunion took place in 1986 at Bassin-Plat on a 150 m elevation site in the southwestern part of the island. There were further introductions on this plot in 1989, with varieties of Hawaiian origin, and in 1990, with varieties collected in a local survey.

In 1990, the collection was partly duplicated at Bassin-Martin (Réunion), on a 300 m elevation site in the same part of the island.

In 1993, a few selected varieties were planted on a smallholder's farm, as part of a CIRAD research programme funded by ODEADOM to investigate litchi cropping under real field conditions. This site is at 300 m elevation in the southeastern part of the island (Sainte Rose).

A number of varieties planted in 1986 have been flowering and producing since 1988. Flowering was also noted in 1992 on trees planted in 1990.

varietal breeding

selection criteria

There are only one, two or three trees representing each variety in the repository, thus fruit quality and earliness of harvest were the main characters that could be selected. Some agronomic features could also be taken into consideration, e.g. earliness of production, tree vigour, graft compatibility on cv Kwaï-Mi, shortness of the fruiting period and productivity. However, the degree of reliability of the results could not be assessed because of the low number of trees/variety tested. Detailed and more statistically-valid analyses of these characters will thus be carried out in the future in experimental orchards cropped with improved varieties.

fruit quality

Fruit quality was defined by the following criteria:

- mean fruit weight,
- fruit size,
- fruit flavour,
- percentage of different fruit components (shell, aril, pit),

Table 1
List and origins of litchi varieties in the CIRAD-FLHOR repository in Réunion.

Variety	Origin	Variety	Origin
Kwaï-Mi	Réunion	Borsworth	Australia
Gros fruit (2)	Réunion	Salathiel	Australia
Lisse (2)	Réunion	Thailand	Australia
Lisse coeur	Réunion	Wai Chee	Australia
Piquant (2)	Réunion	Brewster	Australia and Hawaii*
Tardif	Réunion	Groff	Australia and Hawaii*
Toupie (3)	Réunion	Haak Ip	Australia and Hawaii*
Violet	Réunion		
Litchi X	Réunion	Takafuji	Hawaii
Litchi Y	Réunion	Kwaï Mi Hawaii	Hawaii
		Kawai	(Hawaii)?
A1	Seychelles	Emperor	Thailand
B3	Seychelles		
C4	Seychelles	Bali Planteur	Bali
D1	Seychelles		
D2	Seychelles		
E7	Seychelles	Mauritius	(Mauritius)?
G2	Seychelles	Kwaï Mi Maurice	(Mauritius)?
PDM	Seychelles		
		Litchi Nlle-Caléd.	New Caledonia
Calcutta	India		
Dehradum	India	Kwaï Mi Nialo	
Muzzafapur	India	Kwaï May Pink	
Saharampur	India	Soucytong	
Rose Scented	(India)?	Hueng Lai	
Seedless Late	(India)?		
Bengal	(India)?		

(n) Number of varieties

* Variety introduced as seed

- adhesiveness of the shell to the aril, and the aril to the pit,
- shell and aril colour,
- juice acidity and dry extract,
- aril moisture content.

Analyses were conducted with 11 varieties in 1989, including Kwaï-Mi (NORMAND, 1990b), and 17 varieties in 1991 (BERTIN, 1992).

harvest dates

Earliness of the harvest is an essential consideration for evaluating the spread of the production period. Litchi producers seek early varieties to be able to supply world markets before competing litchi-producing countries in the region, i.e. Madagascar and Mauritius. Late varieties are a drawback because they produce during the cyclone period, which can lead to considerable crop losses.

analysis of tested criteria

The percentages of aril and pit, the main factors studied in the two analyses, were similar in 1989 and 1991 (Table 2). These important qualitative parameters did not seem to vary between years at a given site.

Table 2
Aril and pit percentages for the different varieties in 1989 and 1991.

Variety	Percentage aril		Percentage pit	
	1989 (*)	1991 (**)	1989 (*)	1991 (**)
Kwai-Mi	75.2	70.0	10.3	12.8
Kwai May Pink	64.5	67.5	11.7	11.0
Thailand	62.4	56.5	10.1	25.5
Calcutta	62.7	62.4	15.6	15.6
Bengal	49.7	56.2	18.7	20.4
D2	57.5	60.4	14.1	14.6
Brewster	52.9	56.7	18.1	21.3

(*) Normand, 1990b

(**) Bertin, 1992

The harvest dates for varieties that yielded in 1988 and 1989 (NORMAND, 1990b) and 1991 (BERTIN, 1992) in the Bassin-Plat collection indicated that:

- most of the varieties produced during the first half of December at Bassin-Plat, i.e. almost the same time as Kwai-Mi, which meant a harvest-date gain of only about 10 days over Kwai-Mi (Seychelles variety D2, cvs Dehradum, Mauritius and Kwai May Pink);
- only a few varieties were found to be very early (cv E7 (Seychelles) - mid-November harvest; cv B3 (Seychelles) and cv Bali-Planteur - late November harvest) or very late producers (cv Calcutta - early January harvest).
- harvest dates varied substantially between years, but the spread of the harvest period was not modified for extreme varieties (i.e. very early or late), and only slightly modified for other varieties. This variable is therefore a valid selection criterion.

breeding interesting varieties

Multivariate analyses involving the main quality variables highlighted groups of varieties with similar characteristics (BERTIN, 1992), these were:

- cv Dehradum, cv PDM (Seychelles) and cv Haak Ip: very high quality varieties with high fruit weights, low pit and high aril percentages, and very flavourful fruit;
- cv B3 (Seychelles) and cv Bali-Planteur: with an early harvest date, average acidity and aril percentage;
- cvs Muzzafapur, Rose Scented and Thailand: with low aril and high pit percentages, and low fruit weight.

All other varieties were shared between these groups.

The results revealed:

- varieties with interesting characters: Dehradum, Haak Ip, Kwai-Mi, Kwai May Pink, Soueytong, Mauritius, Bali-Planteur and three varieties from the Seychelles (B3, D2 and PDM). The local variety Kwai-Mi was high in this classification. Two varieties were markedly better than the others, i.e. PDM (Seychelles) and Haak Ip, especially in terms of fruit flavour;
- varieties with characters of little interest for cropping in Réunion: Thailand, Brewster, Sahampur, Calcutta, Muzzafapur, Rose Scented and Bengal. Note that several of these were of Indian origin.

The best varieties, i.e. Haak Ip, PDM (Seychelles), Dehradum and Kwai May Pink, will be planted in experimental orchards for varietal comparisons with cv Kwai-Mi. Production processes of new varieties in the collection will be monitored to add to the present results and determine a set of interesting varieties to improve litchi cropping in Réunion.

varietal characterization

historical background

Litchis are originally from southeastern China. The qualities of this fruit have been renowned for centuries in this country and the first descriptions were Chinese (LIANG, 1981). Chinese names for litchi varieties are very imaginative, but often ignored or changed when they are introduced outside of China: the Chinese name is sometimes translated, for instance cv Hei Ye, means "black leaf", which is its varietal designation in USA; sometimes the original phonetics are kept but the

spelling is changed, e.g. cv Haak Ip comes from the Chinese "Hei Ye", and cv Tai So is derived from "Da Zao"; sometimes the accession is named after the person who first introduced it, such as cvs Groff and Brewster.

Moreover, litchis were long ago introduced in India; this country is probably the second centre where the species diversified. Many litchi varieties have Indian names and it is often quite difficult to determine whether a variety is of Indian or Chinese origin.

There is indeed a great deal of confusion concerning litchi variety names and a detailed morphological description of each variety is necessary to supplement studies on the origins of the present variety names.

Characters that are most often used to identify litchi varieties pertain to fruit descriptions (BATTEN, 1984; ANONYMOUS, 1985; MENZEL and SIMPSON, 1986). They can be associated with vegetative characters to describe the most commonly marketed varieties. SINGH and SINGH (1954) introduced inflorescence-related characters in their descriptions of Indian litchis. However, current descriptions are incomplete and deal chiefly with production; they provide little information to clarify the taxonomy.

research under way in Réunion

CIRAD-FLHOR studies conducted in Réunion since 1989 have focused on fruit characters and, more originally, floral characters. There are several reasons for this choice:

- flowers are commonly used in determination keys,
- floral characters are often the most stable types in various environments (HILU, 1989),
- no detailed studies have been undertaken to date on litchi flowers,
- litchi varietal characterizations could be performed from the flowering stage, which is earlier than the harvest stage.

fruit descriptors

The litchi fruit descriptors defined by NORMAND (1990b) can be divided into two groups (Table 3):

- fruit quality descriptors which are a prime consideration for varietal breeding; these were described above;

- taxonomic descriptors; to unify the descriptions (shapes of fruit, segments and protuberances), these descriptors are generally in line with the conditions set out by MENZEL & SIMPSON (1986). However, some other characters have been added, including the shell suture line and the pit.

These data were recorded for litchis collected in a local survey (NORMAND, 1990a), and for varieties that began fruiting in 1988 (NORMAND, 1990b; BERTIN, 1992).

floral descriptors

NORMAND *et al.* (1990) defined 22 quantitative and qualitative floral descriptors, which are divided into three groups:

- general flower characters, irrespective of the flower type (male or female),

Table 3

List of fruit descriptors used to characterize litchi varieties.

Organ	Descriptor
Whole fruit	Shape of fruit, shoulders ¹ , apex ² Dimensions: length, diameter 1 ³ , diameter 2 ⁴ (mm) Mean fruit weight (g) Percentage of twinned fruit ⁵ Suture line on the fruit: marked, barely visible, undetectable Percentage of different components: shell, aril, pit
Shell	External colour at maturity Internal colour at maturity Thickness (mm) Protuberances: general shape ² , length and width at the base, height, number/cm ²
Aril and juice	Shell-aril adhesion: strong, average, weak Aril-pit adhesion: strong, average, weak Colour Soluble dry extract at maturity (E) in °Brix Acidity at maturity (A) in meq/100 ml E/A Flavour Moisture content (% fresh weight)
Pit	Pit description: shape, colour Dimensions: height, diameter 1 ³ , diameter 2 ⁴ Percentage aborted pits

(1) swelling at the peduncle

(2) see MENZEL and SIMPSON (1986)

(3) diameter along the suture line axis

(4) diameter perpendicular to diameter 1

(5) fruit with both ovaries developed, thus forming a double-joined fruit

- characters and conditions specific to male flowers,
- characters and conditions specific to female flowers.

The flower sampling and monitoring techniques for measuring quantitative characters are described by NORMAND *et al.* (1990).

These data were recorded for 11 varieties in the Bassin-Plat collection in 1989 (NORMAND *et al.*, 1990) and for 36 varieties, including 23 from the Bassin-Plat collection and 13 from the young Bassin-Martin collection, in 1992 (COMMON, 1993).

data management

The quantity of fruit and flower data recorded is very important, and they should be computerized for efficient management. The LITAID software program was developed by the CIRAD-FLHOR biometry service (NORMAND *et al.*, 1990). It is a derivative of the MUSAID program that was designed to manage morphotaxonomic data and provide an identification aid for banana (PERRIER & TEZENAS DU MONTCEL, 1988).

LITAID has the same two main functions as MUSAID:

- fruit and flower data can be managed;
- it is an identification aid which enables the operator to match an unknown plant with an already identified and described variety, with a reasonable margin of error.

The operating principle is the same as that of MUSAID. The unique aspect is that each descriptor is provided with an error matrix, weighting it relative to its reliability. A descriptor with two distinct stable conditions will thus have a low error function; in contrast, when two or more conditions are difficult to distinguish or are not very stable, the error function will be higher.

Determining the error matrix for each descriptor is a critical step because it clearly specifies the degree of reliability and quality of identifications for unknown plants.

After the second set of observations in 1992, these error matrices were refined as a function of the descriptor reliability and

stability results. It seems that quantified descriptors are generally only useful for comparisons of extreme values (COMMON, 1993).

LITAID has a no-answer function which enables identifications with only a few descriptors.

The program includes a module to calculate phenotypic distances; this is the mean distance between two individuals, for all descriptors, weighted by the associated error functions. This distance is not a real distance in mathematical terms, because at zero there is no probability in the matrix. The distance only indicates the extent of convergence or divergence of the studied character for two individuals within the reliability limits of these characters.

varietal choices

validity of some floral characters

The initial flower results highlighted some intervarietal diversity in the floral characters (Photo 1), which led to the development of a determination key for the 11 varieties studied (NORMAND *et al.*, 1990). The first two dichotomies of this key are based on two stable characters, stamen number and colour of the nectariferous disk, under clear-cut conditions; they are also independent of the flower type and easy to monitor.

Following the second set of observations (COMMON, 1993), the validity of the descriptors was assessed by studying flowers of certain varieties grown at the same site (Bassin-Plat) at 3-year intervals, and at two different sites (Bassin-Plat and Bassin-Martin) during the same year.

Comparisons of descriptions of the same variety for different years and different sites revealed the high stability of two characters, i.e. the colour of the nectariferous disk and the anther shape. Other characters were found to be relatively stable, i.e. anther length on male flowers, stamen number and calyx colour (COMMON, 1993).

The conditions associated with each variable were also defined in further detail on the basis of the latter results.

determining groups

Three groups were determined on the basis of the calculated phenotypic distances between 22 varieties from the Bassin-Plat collection (COMMON, 1993).

Two very close groups, which differ in terms of the colour of the nectariferous disk, are formed by Kwai-Mi type varieties: one includes cvs Kwai-Mi, Kwai-Mi Maurice, Kwai-Mi Nialo, Takafuji, B3 (Seychelles), and three locally-collected varieties (cvs Gros Fruits n°2, Litchi Tardif and Litchi Piquant); the other includes cvs Mauritius, PDM (Seychelles), Haak Ip and Dehradum.

The third group comprises three varieties of Indian origin, cvs Calcutta, Bengal and Rose Scented.

Although incomplete, since only the floral characters were taken into account, the present results are of interest for the study of genetic resource diversity in litchi. Moreover, varieties that were grouped on the basis of their highly convergent floral characters also had similar fruit characters. The fruit produced by varieties Kwai-Mi Maurice, Kwai-Mi Nialo, B3 (Seychelles), Gros Fruits n°2 and Litchi Tardif, classified in the first cv Kwai-Mi related group, was similar to that produced by cv Kwai-Mi and only differed in their sizes and mean fruit weights. The fruit of cv Takafuji has not yet been studied. The locally-collected cv Litchi Piquant was the only one of this group to differ markedly from cv Kwai-Mi in terms of fruit and leaf characters.

Similarly, in the second group, cvs PDM (Seychelles), Haak Ip and Dehradum have already been grouped according to fruit-related criteria considered for varietal breeding purposes.

prospects

At various locations in Réunion, CIRAD-FLHOR has a large repository of litchi varieties of different origins. The first accessions have already been bred to produce four hybrids of the same quality as the local variety Kwai-Mi, but they can be harvested slightly earlier.

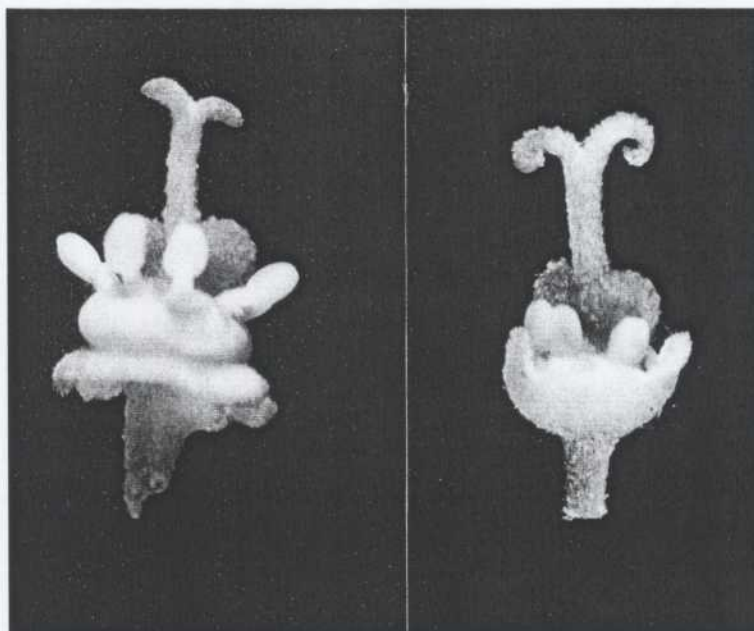


Photo 1.
Female flowers for cv Kwai-Mi (left) and a variety from the Seychelles (right).
Note the marked morphological differences in the shape of the calyx, protuberance of the nectariferous disk, length of the stamen filaments, length and shape of the stigma.

Varietal studies using fruit and floral descriptors are currently under way. This work is facilitated by the LITAID software program that was designed to manage morphotaxonomic data and to serve as an identification aid. It now handles flower and fruit data for several varieties. Groups can be determined on the basis of the stable reliable floral descriptors.

One of the main objectives now is to enhance the characterizations with new phenotypic, vegetative and inflorescence descriptors, and with biochemical markers.

The current system could be optimized and utilized by:

- reducing the number of descriptors used in flower studies,
- analysing the results already obtained on fruit and on fruit/flower combinations,
- comparing local results with those obtained elsewhere in the world,
- building up the reference data bases.

New litchi varieties should be rationally introduced in Réunion to enable continuous selection of well-adapted varieties and broaden the scope of varietal characterization research. ●

Figure 1
Description sheet for cv Kwai-Mi floral characters produced by the LITAID software program.

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