Evaluation of Lapsi tree (*Choerospondias axillaris,* Roxb.) for fruit production in Nepal

K. C. Paudel, K. Pieber, R. Klumpp and M. Laimer

Bewertung von Lapsi (*Choerospondias axillaris,* Roxb.) zur Obstproduktion in Nepal

1. Introduction

Lapsi (*Choerospondias axillaris*) is a large, deciduous, edible native fruit tree of the family *Anacardiaceae.* Native to Nepal hills (850–1900 m asl), the tree has also been reported from India, China, Thailand, Japan and Vietnam. Nepal is unique for processing and use of Lapsi fruits. Fruits are rich in vitamin C content (SHAH, 1978), and are consumed fresh, pickled and processed for preparing a variety of sweet and sour, tasty food products locally called as *Mada* and candy. The candy products are usually prepared from the mesocarp of ripe fruits and are popular among women, children, trekkers and tourists in Nepal. Lapsi wood is used as light construction timber and fuelwood; seedstones are used as fuel in brick kilns and the bark has a medicinal value (NGUYEN et al., 1996). Fruit products are presently consumed mostly within the country but have potential for international market promotion. The annual transaction of Lapsi fruit, in Kathmandu alone, is estimated worth over 50m Nepalese Rupees (approx. 0,65 m US$; BM, 1999).

Lapsi has great potential as a cash generating tree for hill farming communities in Nepal (PAUDEL and PARAJULI, 1999; LARC, 1997). The tree has been considered as suitable crop for multiple use in mountain farms and the Nepalese government has emphasised the production and processing of such high value agroforestry products (APP, 1995).

Zusammenfassung

Choerospondias axillaris, Roxb., ein großer, mehrjähriger, zweihäusiger subtropischer Baum wurde als potentieller Obst- und Forstbaum identifiziert, der für Kleinbauern in Nepal eine zusätzliche Einkommensquelle darstellen könnte. Der Baum, der in Nepal *Lapsi* genannt wird, erzeugt Früchte mit einem hohen Gehalt an Vitamin C, die entweder frisch, eingelegt oder zu einer Vielzahl von süßen, sauren oder würzigen Lebensmitteln verarbeitet, verzehrt werden.

Um *Lapsi* für die Nutzung durch Kleinbauern zu domestizieren, wurde zunächst das vorhandene einheimische Wissen über Anbau, Verwendung, Fruchtverarbeitung, Vermarktung und vor allem über Vorkommen und Verbreitung in Nepal untersucht und dargestellt. Basierend auf dem Wissen der Bauern wurden Varietäten von *Lapsi* identifiziert, Kriterien zur Unterscheidung von männlichen und weiblichen Pflanzen im Sämlingsalter gesucht und Verarbeitungsmethoden präsentiert. Eine Verteilungskarte von *Lapsi* in Nepal wurde angelegt, wobei über 450.000 Bäume, die derzeit in kleinen Farmen und Gemeindewäldern wachsen, erfasst wurden.

Als erster Schritt zur Domestikation wurde mit der Identifikation, Selektion und Bewertung von Elite-Mutterbäumen begonnen und ein Züchtungsgarten mit Sämlingen von 52 ausgewählten Bäumen angelegt, um die Genressourcen zu erhalten. Vegetative Vermehrungsmethoden zur raschen Vermehrung selektierter Bäume wie Okulation, Pfropfung, verschiedene Stecklingsvermehrungen und Gewebekultur wurden verglichen. Von allen angewandten Methoden war die „Chip-budding"-Methode, wenn sie in den ersten drei Februarwochen durchgeführt wurde, am erfolgreichsten (bis zu 90 %), gefolgt von Grünstecklings- (40 %) und Stecklingsvermehrung (7 %). Axenische Kulturen von *Lapsi* wurden auf DKV Medium mit 1mg/l Benzylaminopurin (BAP) in vitro etabliert, und die Vermehrung der Sprosskulturen unter verschiedenen Kulturbedingungen wird derzeit untersucht. *Lapsi* wurde als Baum mit potentiellem Wert für Obst- und Forstnutzung erkannt und zur Domestikation ausgewählt.

Schlagworte: *Choerospondias axillaris,* Roxb., Lapsi, vegetative Vermehrung, Obstbäume, Domestikation.

Summary

Choerospondias axillaris (Roxb.), a large, deciduous, and dioecious sub tropical fruit tree has been recognised as a potential agroforestry tree for income generation for subsistence farmers in Nepal. The tree, locally called *Lapsi,* produces fruits with high vitamin C content, which are consumed fresh, pickled and processed for preparing varieties of sweet and sour, tasty food products that are marketed locally and have potentials for exporting.

With the objective to domesticate this tree for small holders benefit, the status of indigenous knowledge about cultivation, management and utilization, fruit processing and marketing as well as occurrence and distribution in Nepal were studied and presented. Based on farmers knowledge, varieties of *Lapsi,* their sex determination criteria and processing practices are identified and presented. A distribution map of *Lapsi* in Nepal was prepared from over 450,000 trees already growing in farms and community forests.

As first step towards domestication the identification, selection and evaluation of superior mother trees has been initiated and a Breeding Seed Orchard with 52 selected trees has been established to conserve the selected germplasm. Vegetative propagation methods for multiplying selected trees were studied using budding, grafting, hardwood and softwood cutting propagation and tissue culture. Among all techniques studied, chip budding during the first three weeks in February was most successful (up to 90 %), followed by softwood (40 %) and hardwood (7 %) cutting propagation. Axenic cultures were established *in vitro* using DKV medium supplemented with 1mg/l of BAP and further multiplication of cultures under different culture conditions is currently being studied. Lapsi has been recognised as a potential agroforestry tree for domestication.

Key words: *Choerospondias axillaris*, Lapsi, vegetative propagation, fruit trees, domestication, agroforestry.

The tree is dioecious, but it is difficult to distinguish male and female plants at the seedling stage (AGRAWAL et al., 1991, 1992). Since information about occurrence and distribution of Lapsi trees in Nepal are scanty, we have identified the major Lapsi growing areas in the country, the major centers for fruit production, processing and marketing, and we have highlighted the limitations to further expansion of Lapsi cultivation in Nepal (PAUDEL et al., 2002).

As an early step in domestication it would be desirable to vegetatively propagate selected mother trees to conserve and utilize their genetic potential. This may be achieved by budding, grafting, propagation of hardwood or softwood cuttings or by tissue culture.

This paper presents key findings of the research on various aspects of Lapsi domestication in Nepal including germplasm collection, evaluation, and documentation of local knowledge about Lapsi growing, occurrence and distribution Lapsi in the country, and development of vegetative propagation method to multiply selected Lapsi trees.

2. Materials and Methods

To document occurrence and distribution of Lapsi in Nepal, a postal survey was carried out in 51 hill districts, followed by field visits, personal contacts and secondary sources of information.

A semi-structured questionnaire survey (PAUDEL et al., 2002) with 45 Lapsi growers in 3 villages (Kusadevi-Rayale (1500 m) and Chhaimale (1200 m) in Central Nepal and Barang (900 m) in Western Nepal) was carried out to collect and evaluate local knowledge about Lapsi ecology, husbandry and marketing. This was followed by 3 focus group discussions in each village using Participatory Rural Appraisal (PRA) techniques (MESSERSCHMIDT and HAMMET, 1998) and a key informant survey in 3 major marketing centers (Kathmandu, Pokhara and Sanga) providing an overview on marketing, trading and processing of Lapsi in Nepal.

To identify, select and evaluate elite materials, seven villages in the middle hills of Nepal were selected on the basis of available information on Lapsi production. A combined trek appraoch of experts, involving an agro-forester, a horticulturist and a socio-economist was organized using PRA techniques, informal discussions with Lapsi growers and direct observation of the candidate trees in the study villages. Farmers and expert quality criteria were combined to reach consensus on the ranking of the 10–12 best trees per site.

To develop vegetative propagation methods for elite female plants, field and laboratory experimentation using standard statistical design and analysis procedures were carried out in Godawari and Pokhara in Nepal and in Vienna. Budding and

grafting, propagation by hardwood and softwood cuttings were compared and tissue cultures were initiated. An experiment to study the effects of time and type of grafting methods was conducted during the winter months of 1999 in Godawari and Pokhara. Two methods of grafting (chip budding and side grafting) were tried at 6 different time intervals of 10 days (from 10. 01. 1999 until 03. 03. 1999) in a 2x6 factorial experimental design with 4 replications of 25 plants in each plot. Hardwood cutting propagation using different rooting hormones was carried out in Godawari and Vienna under conventional nursery conditions and in the greenhouse. Similarly, a 3x4 hormone experiment was carried out in a locally developed mist propagator at Godawari, Nepal.

Tissue cultures were initated using axillary buds from selected trees in the Plant Biotechnology Unit of the Institute of Applied Microbiology, Vienna.

3. Results

3.1 Occurrence and distribution of Lapsi in Nepal

A total of 301 Village Development Committees in 29 hill districts have reported cultivation and protection of Lapsi trees for some socio-economic purpose. Lapsi was grown from east to west Nepal from 850 m asl to up to 1900 m. Distribution of Lapsi has been found in much wider areas in the country than reported earlier. Over 40,000 trees are at fruit bearing stage and more than 450,000 new trees are planted in these districts. There is a tremendous opportunity for income and employment generation through proper management and use of Lapsi tree.

A distribution map of Lapsi at national and VDC level has been produced for the first time in Nepal (Figure 1). Accordingly, high intensity Lapsi production areas can now be selected and be used as potential seed production areas. Major Lapsi production areas, fruit processing locations and market centres for fresh and processed fruit products have been identified and documented. Lack of technical know-how, extension support, uncertainty of fruiting, unavailability of planting material, long gestation period and lack of market were identified as major limitations to the expansion of Lapsi cultivation.

Information collection about distribution of a high value agroforestry tree at national level using participatory approach through existing government forestry network and their staff has been proven to be a time and cost effective way of starting domestication efforts in a resource-poor country like Nepal. Detailed results of this activity are available in PAUDEL (2000, 2001).

3.2 Acquisition of indigenous knowledge about cultivation, management and use of Lapsi

Local farmers of both male and female genders have a wealth of knowledge about Lapsi cultivation, management and utilisation, depending on their involvement in various

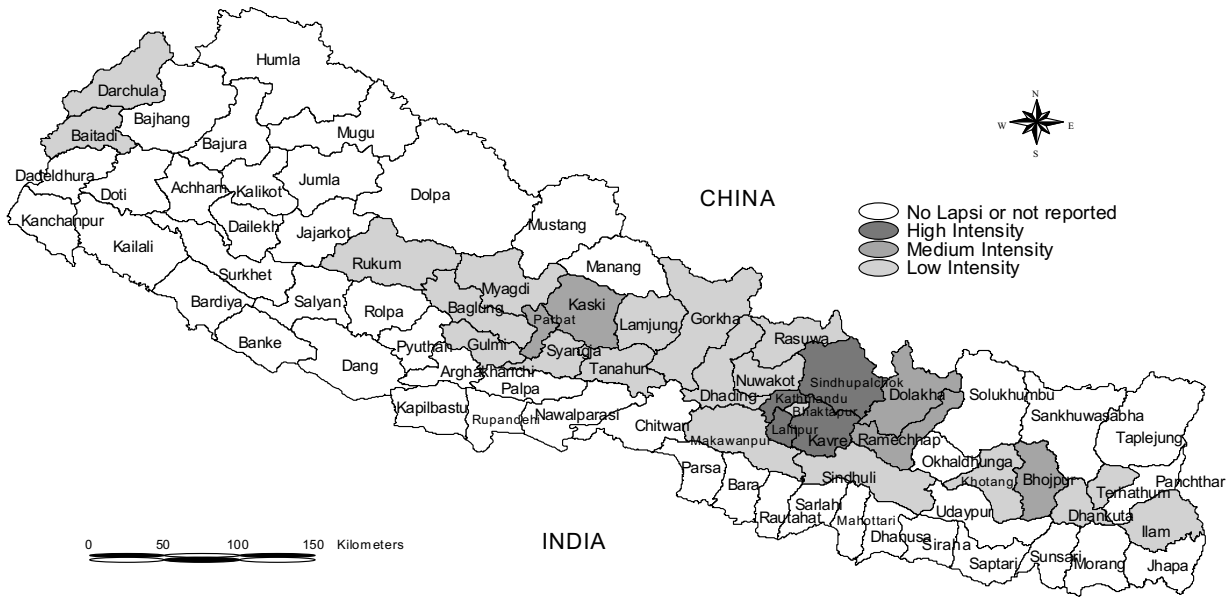

Figure 1: Distribution of Lapsi in various districts of Nepal
Abbildung 1: Verbreitung von Lapsi in verschiedenen Distrikten von Nepal

activities of Lapsi production and marketing. Almost all Lapsi fruit reaching the market to-date originated from wild grown trees. Farmers have been protecting and growing spontaneously grown Lapsi plants in forests and farmland. They have increased Lapsi cultivation for the last 10-20 years, especially since forest nurseries begun to produce and distribute Lapsi seedlings. Lapsi is planted in conventional forestry practice without much care except protection against livestock. No evidence for use of improved technologies/varieties for quality fruit production nor for horticultural practices such as irrigation, fertilisation and pruning was found in Nepal.

Lapsi is considered as one of the best agroforestry tree species to be grown in farmlands for several reasons, e.g. it has a thin crown density, it forms tall and deciduous trees causing little shading effects on cereal crops. However, disadvantages of growing Lapsi in farmland were also realised by farmers: crop damage occurs at Lapsi harvest, crop impact of Lapsi trees is noted in bari lands (un-irrigated farms). Farmers try to minimise these effects by planting trees on the margins and corners of farmland and pastures.

Lapsi is mainly grown for its fruits in market accessible areas and for timber and fuelwood in other areas. Leaves were sometimes used as fodder for goats only. Farmers prefer timber from female trees, as they consider it to be stronger and attractive in colour. Fruits are harvested from September until January depending upon the market demand and fruit maturity, however before complete ripening to avoid losses such as fruit rupture and rotting when harvested at full ripeness. Lapsi fruits are eaten as fresh fruit, pickled, chutney, *mada* and candy. More than a dozen food items are prepared from Lapsi fruits to be used as souring agents, squash, candy etc. Seed stones extracted from Lapsi fruits are reported to be utilised as wood fuel for boiling Lapsi fruit while processing, cooking meals and also in brick manufacturing.

Lapsi cultivation has been much influenced by marketing facilities such as access to motor road and market centers, processing companies and traders activity (PAUDEL, 2000). The extensive cultivation of Lapsi around the districts of Kathmandu valley, and its catchment area provide an absolute evidence on positive influence of market facility on Lapsi production.

Farmers have categorized Lapsi in to different types according to their indigenous indicators that are based on fruit size, time of maturity and fruit quality (Table 1). Biochemical analyses confirmed these distinctions as valid selection criteria (PAUDEL et al. 2002).

Table 1: Criteria used by farmers for the distinction of Lapsi types
Tabelle 1: Unterscheidungskriterien für Lapsi

Fruit quality riteria	Type
Fruit size: small and large	*Sano* and *Thulo* Lapsi
Fruit maturity: early and late	*Aghaute* and *Pachaute*
Taste of fruit: sweet and sour	*Guliyo* and *Amilo*
Pulp content: high and low	*Bose* and *Hade*

Early sex determination of Lapsi at seedling stage was considered a major problem for increased fruit production by farmers in all sites. Inquiries about indigenous knowledge on this item have indicated some morphological differences between two sexes (Table 2). Accordingly, Nepalese farmers call female plants *Pothi* Lapsi and male plants *Bhale*. These indications need further testing and verification at a larger scale.

Table 2: Morphological differences observed by farmers between bearing (female) and non-bearing (male) trees
Tabelle 2: Morphologische Unterschiede zwischen weiblichen und männlichen Bäumen

Morphological criteria	*Pothi* Lapsi (bearing) female	*Bhale* Lapsi (non-bearing) male
Leaf emergence	later	earlier
New leaf color	yellowish	purple/reddish
Leaf margin	entire	mostly serrated
Color of latex	milky, thick	watery, thin

3.3 Processing, marketing and trading of Lapsi products

Fruit processing is taking place at domestic, semi-commercial and commercial scale. Farmers in remote areas are traditionally processing Lapsi for household needs as pickles (both fresh and packed), and mada. Mada is a collective name for dried Lapsi mat prepared from the pulp/peel of Lapsi fruits by crushing in a wooden mill (*Dhiki*), often mixed with salt, sugar or spices, sun dried, packed and sold in markets as dry fruit products.

The production and sale of Lapsi fruits for processed products such as *mada,* candy and *titaura* is confined around urban areas, whereas local sale and bartering of Lapsi fruit for salt, sugar, cereals and stationary has been reported to take place even in remote areas. New processing companies are established in smaller town centers, as road network is being expanded.

Most of the Lapsi products are consumed within Nepal. However, the possibility for exporting Lapsi products could

be improved with better management and processing practices. The main marketable products are: *Mada*, Candy, *Titaura*, *Lassipau*, Lapsi powder, Lapsi squash etc.

3.4 Selection of superior mother trees and their conservation

Selection criteria for elite mother plants were based on farmers perception of fruits and trees, but also processors' preferences including size, appearance, pulp content, color, sugar content and health status. Farmers have a range of selection criteria, mainly based on the quantity of Lapsi production per tree, as this means value in monetary term, associated with fruit size, fruit retaining quality until maturity, insect and disease tolerance. Farmers considered as quality criteria also the taste and appearance of the fruit, and the ripening season etc.

Lapsi growers were aware of high and low pulp content of fruits. Lapsi trees producing fruits with a high proportion of pulp were termed as *Bose Lapsi* and trees producing fruits with high proportion of stone were called as *Hade Lapsi*. However, this concept of *Hade* and *Bose Lapsi* was independent of fruit size. Farmers preferred *Bose Lapsi* for fruit production. Early variety (*Aghaute*) were preferred by most farmers as it fits to the main festival time in Nepal, when they can harvest and sell Lapsi to meet their household needs.

Most farmers ideotype for fruit production was a tree with several branches from the base, considered to be easier to harvest and producing more fruits. However, some farmers argued taller trees fitted better in farmland, as they allowed more light to the food crop underneath and also provided larger volumes of timber when felled.

Fruits from selected trees were collected and evaluated for their shape, size, pulp content, appearance and deformities. Laboratory analyses of the fruits showed a great variation in fruit size, weight (8-18 gm), pulp, and acid/sugar content (PAUDEL, 2001).

Based on farmers and experts criteria, 81 superior mother trees have been selected. Seeds from these trees were collected, germinated and planted as a half-sib Breeding Seed Orchard (BSO) in a community forestry plot, under the auspices of the Tree Improvement and Silviculture Component (TISC) of the Department of Forests in summer 1998 at Malepatan, Nepal. Today the BSO contains plants from 52 mother trees, ensuring the conservation of selected germplasm. However, this is just the beginning and more selections should be added, as more information about elite trees becomes available.

3.5 egetative propagation of Lapsi

3.5.1 Propagation by budding and grafting

Among various methods tested, chip budding showed the best results (up to 93 % success) when carried out during the first three weeks of February (Fig. 2). The effect of both propagation techniques and the time was significant (p = 0.000), since side grafting done at the same time under similar conditions gave a much lower success rate (7 %).

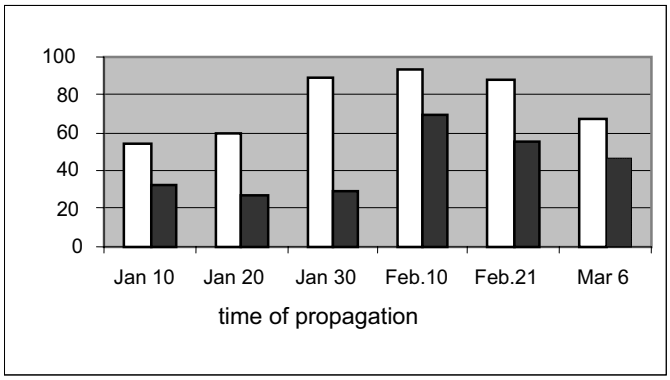

Figure 2: Effect of the season on the success rate of bud grafting (in %) of Lapsi at Pokhara (black bars) and Godawari (white bars) in Nepal

Abbildung 2: Einfluss der Jahreszeit auf die Anwuchsrate bei Veredlungen (in %) von Lapsi in Pokhara (dunkle Balken) und Godawari (weiße Balken) in Nepal

Chip budding of 22 selected female and 20 male trees of varying age (10 – >150 years) has proved to be a successful method of propagating Lapsi trees of any age. Hence, this method can be highly recommended, since it can be carried out easily by moderately trained personals over a prolonged period each year (PAUDEL, 2001).

3.5.2 Propagation of hardwood cuttings

Effects of different rooting hormones on hardwood cutting propagation of Lapsi, both in open field and under polythene-cover condition were successfully studied for the first time in Nepal. Rooting occurred when cuttings were treated in Seradix-B3, and planted in the third week of January in conventional forest nursery conditions. Evidence of rooting even without rooting hormone was observed in an

glasshouse experiment in Vienna. Because the rate of success during the first round of experimentation was low (7 %), further investigations are required.

3.5.3 Propagation of softwood cutting

Rooting experiments in a locally designed mist propagator showed about 40 % rooting in perlite medium, when softwood cuttings were treated with 2000 ppm IBA. However, similar experiments under non-mist propagator systems in sand media failed to produce roots. Cuttings rejected their leaves within 6–14 days after planting and over 90 % died within a month (PAUDEL, 2000). Softwood rooting in Lapsi is possible but needs a greater care and specific rooting environment (PAUDEL, 2001).

3.5.4 Propagation by tissue culture

Attempts in tissue culture of mature Lapsi trees using axillary buds from selected male and female trees have been initiated at the Institute of Applied Microbiology, University of Natural Resources and Applied Life Sciences, Vienna, since 1998. So far, surface sterilisation procedure for the explants derived from grafted plants at different maturity stages have been developed. Axenic cultures could be successfully established in DKV medium (DRIVER and KUNIYUKI, 1984) supplemented with 1 mg/l benzyl-aminopurine (BAP). Studies on further development and multiplication of shoots under the influence of different hormone combinations and culture conditions are currently underway.

4. Conclusions

The occurrence and distribution of Lapsi in Nepal has been documented. This has opened a venue for identifying and establishing seed stands at different agro-ecological regions. Current status of local knowledge about Lapsi cultivation, management, fruit processing and marketing has been collected, evaluated and documented, which can now be used as a basis for selecting elite trees and developing research and development agenda to promote Lapsi as a cash crop. Methods for selecting superior Lapsi trees have been established and identification, evaluation and conservation of elite trees have been initiated. However, conservation of elite clones should be continued when more information becomes available. Vegetative propagation methods for selected trees have been identified and mass scale propagation using tissue culture techniques are being developed.

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