Technical Manual No. 23

Growing Tamarind Trees:
A handbook for the Sahelian Horticulturist

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World Agroforestry Centre (ICRAF)

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WORLD AGROFORESTRY CENTRE (ICRAF)

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Foreword

As part of national systems capacity building program to conduct agroforestry research, training, education and communication in agroforestry, the World Agroforestry Centre - West and Central Africa (ICRAF-WCA), in collaboration with its research partners, develops appropriate agroforestry techniques that help improve family incomes and their food and nutrition security while preserving the environment.

Since 1989, a wide range of agroforestry technologies have been developed to meet the challenge of increasing and diversifying farmers' resources and incomes.

To facilitate the dissemination and adoption of agroforestry innovations and to strengthen the capacity of producers in the Sahel, ICRAF-WCA / Sahel has developed data sheets as training tools.

The tamarind tree can be propagated by seed (seeds) or asexually (cuttings, layering and grafting). However, grafting is the most known vegetative or asexual propagation method for tamarind tree. In collaboration with the research institutes of Burkina Faso [Institute for Environment and Agricultural Research (INERA)], Mali [Institute for Rural Economy (IER)], Niger [National Institute for Agronomic Research of Niger (INRAN)] and Senegal [Senegalese Institute for Agricultural Research (ISRA)], domestication techniques of various agroforestry species including *Tamarindus indica* L. were conducted.

Each step of grafting is described and illustrated by photographs. Periods favorable to the multiplication of these tamarind cultivars are also mentioned. Grafting is an operation that requires thoroughness and patience. But efforts made are quickly rewarded by an abundant production of quality fruits.

Improved tamarind accessions with a high content of various nutrients (calcium, iron, carbohydrate, lipid, magnesium, phosphorus, potassium, protein) have been successfully introduced from Burkina Faso, Brazil, Reunion Island, Kenya, Mali, Niger, Senegal and Thailand.

hese accessions all have genetic characteristics such as size, earliness and nutrients. Some accessions flower and grow after only one year after grafting (five to eight years for the local variety).

This document deals mainly with tamarind growing techniques and more particularly with grafting techniques. While seed propagation allows for genetic diversity, cuttings and grafting can reproduce individuals with identical traits. These techniques make it possible to increase tamarind yields using more productive plant material and good management of the tree. As a result, nutritional quality is improved and will thus help reduce poverty in rural communities.

Users of this manual are invited to send their comments to the ICRAF-WCA / Sahel team for the improvement of this document in a future edition.

Authors

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- the national research institutions of Burkina Faso, Mali, Niger and Senegal through the human resources available to structures such as the Institute for Environment and Agricultural Research (INERA), the Institute for Rural Economy (IER), the National Institute for Agricultural Research of Niger (INRAN) and the Senegalese Institute for Agricultural Research (ISRA);
- the following NGOs and development projects: ADAF-Gallè; Association Malienne pour la Sécurité et la Souveraineté Alimentaire (AMASSA/Afrique Verte) ; Association Malienne d'Eveil pour le Développement Durable (AMEDD); Association des Femmes pour l'Éducation et l'Environnement (AFEE); Association des Pépiniéristes Urbains de Ségou ; Association des Pépiniéristes Urbains et Périurbains de Bamako ; Coordination des Associations des Femmes et ONG Féminines (CAFO) ; Helvetas Swiss-Intercooperation; Peace Corps Mission; Organisations Paysannes (OP); Programme d'Appui aux Filières Agricoles (PAFA); World Food Program (WFP); Projet Villages du Millénaire (PVM); SahelEco; Filles du Cœur Immaculé de Marie (FCIM) of Kati and San; World Vision International (WVI).

We also express our gratitude to all those men and women with long experience in research, naturalistic knowledge and development, who have had the patience to pass on all their knowledge on this forest fruit species that has great potential in the Sahel.

We also thank Mahalmadane Djitèye (Ecologist), for review and comments on this manual.

Acronyms and Abbreviation

AFEE	Women's Association for Education and the Environment
AMASSA	Malian Association for Food Security and Sovereignty
AMEDD	Malian Awareness Association for Sustainable Development
CAFO	Coordination of Associations for Women and Women's NGOs
FAO	Food and Agriculture Organization
FCIM	Filles du Cœur Immaculé de Marie
GIE	Economic Interest Grouping
ICRAF-WCA	World Agroforestry Centre, West and Central Africa
IER	Institute for Rural Economy
INERA	Institute of Environment and Agricultural Research
INRAN	National Institute for Agricultural Research of Niger
IPR/IFRA	Rural Polytechnic Institute / Institute for Training and Applied Research, Katibougou
ISRA	Senegalese Institute of Agricultural Research
NGO	Non-Governmental Organization
OP	Farmers' Organizations s
PAE	Agro Ecological Project
WFP	World Food Program
PVM	Projet Villages du Millénaire
WVI	World Vision International

General Introduction

Origin and summary description of the tamarind tree

The tamarind tree is a majestic one, with leaves including many small leaflets of a beautiful soft green colour closing at nightfall.

Scientific Name: Synonyms:	*Tamarindus indica* L. *Tamarindus occidentalis* (Gaertn); *Tamarindus* (Hook) and *Tamarindus unbrosa* (Salisb)
Group :	Caesalpinaceae
English Name:	Tamarind Tree
Local Names:	*N'tomi* (bambara); *Mungnun* (bore); *Budahar* (diola) ; *Bupugubu, Pusga* (moré) ; *Sog* (sérère) : Dabè, *Diami, Djatabé* (fulfulde) ; *Dakak, Dakkar* (wolof) : Basoro, *Bassasu, Bochocho* (tamashek)

Originally from India, tamarind *(Tamarindus indica)* is widespread throughout tropical dry Africa and tropical Asia, giving the impression that it is a domestic species from the driest savannahs of tropical Africa. It is a 15 to 20 m high tree, hemispherical very thick, branched from the base in a cluster of ascending branches. Its greyish bark is very cracked and scaly. The alternate leaves bear 9 to 12 pairs of smooth glabrous leaflets at both ends. Pods are thick, woody, often curved and slightly flattened.

The tamarind tree grows well on a varied range of soils and climatic conditions but prefers the semi-arid zones and the grassed meadows. It is generally found on soils composed of light clay (especially red clay), fine silt, sand or alluvium, as well as in rocky areas.

It prefers well-drained alluvial soils with an average rainfall of 250 to 1200 mm per year. It grows on an altitude ranging from 0 to 1,600 m above sea level. In dry areas, the species thrives along streams. It is found in Africa, Southeast Asia, the West Indies, Arab countries and the Caribbean. The word tamarind comes from the Arabic language tamar hindi meaning "date of India", country where this fruit has been cultivated since prehistoric times. Kitchens of several Asian countries and the Middle East make a great use of tamarind. The tamarind fruit is known for its medicinal properties and is very popular in syrup, fruit paste, sherbet or in many other culinary uses.

Composition and main uses of the species

The fruit pulp has exceptional calcium content and also contains many other elements such as phosphorus. The tamarind is enclosed in almost cylindrical, reddish-brown pods that are 10 to 15 cm long and containing up to 12 hard, shiny, dark cinnamon seeds. The seed pulp is compact and contains some fibrous filaments. Acidic, it is both sweet and very tart. The fruit pulp is very rich in tartaric acid and is used as a preservative in the fruit and vegetable industry. The green, hard pulp of immature fruits is too sour to be consumed directly, but is often used for cooking tasty dishes. Ripe fruits are edible and popular because they are sweeter, but still very acidic.

They are used in desserts in the form of jam, pressed to make juices or sugary drinks. They are also used as a natural laxative. The fruits are directly consumed. They are used as ferments of cereal porridge and make appetizing other dishes. Tamarind fruit can have a more significant impact on reducing the vulnerability of farmers if its production is more profit-oriented. The tooth-picked stem relieves toothache and fruit juice treats constipation.

Figure 1: Grafted accession, Niger 309, in fruit, 1 year after planting

Figure 2: Tamarind fruit
a: local of Mali

b: exotic
(Sweet Thailand)

A tamarind fruit (100 g) contains: Energy (176Kcals); Water (21.4 g); Protein (4.4 g); Carbohydrate (41 g); Lipid (0.5g); Potassium (523 mg); Calcium (122 mg); Magnesium (70 mg); Iron (3.1 mg); Phosphorus (119 mg). A tree with multiple uses and highly sought after by the population; it is used as lumber and service and provides a good firewood and charcoal. Table 1 summarizes some uses and the related parts. By virtue of its utility, tamarind has been identified as one of the priority species with high domestication potential in the Sahel (Van Bilcke et al., 2014).

Table 1: Common Uses and Desired Parts of Tamarind tree

Consumption	Plant parts
Food	Fruits, leaves
Conservation	Fruits
Forage	Pods, leaves
Firewood and work	Branches, stems, trunk
Pharmacopoeia	Leaves, fruits, bark, roots
Fishing	Flowers
Soil protection, decoration	Whole tree

Despite the high value and widespread use of the species, little is known about the genetics of African populations. Fruits in dry areas have less pulp than those in humid areas and fruit characteristics are affected by climate and soil type (Van Bilcke et al, 2014). Early studies established that it was a diploid species with 24 chromosomes. Preliminary results of provenance tests in Burkina Faso, Mali, and Senegal indicated large variation in growth, biomass, and fruit production based on seed origin (Muok and Alem, 2011) but these results have not been published yet.

Accessions introduced in the Sahel

To increase the production of tamarind in the Sahel, the World Agroforestry Centre (ICRAF), through its Sahel Node and its partners, has introduced new accessions in the sub-region. These introductions include accessions from Burkina Faso, Brazil, China, Kenya, Niger, Reunion Island, Thailand and Vietnam. Some of these accessions (Niger 309, Sweet Thailand, Thailand Gros-fruit and Vietnam 3) are disseminated in farmland, the rest being observed on station in Samanko, Bamako, where all accessions are kept in a genebank. Their vegetative characteristics as well as the estimated fruit production are described in figures 3a-3k.

The weight in kilograms of fruit varies according to the seasons and the accessions.

Figure 3a: Accession Kodiéna (Burkina Faso) Leaflets elongate, light green. Branchy trunk; pods long, thin and very acidic. The weight of a pod varies from 3.5 to 8.1 g.

Figure 3b: Accessions KTN 2 (Kenya) Leaflets dark green, coriaceous, blackish trunk, rough, broom shaped. Small pods, little acid. The weight of a pod is between 4.1 and 8.2 g.

Figure 3c: Accession Niger 305 Short greenish leaflets, blackish trunk. Early fall of the leaves. Pods large, slightly whitish. The weight of a pod varies between 8.2 and 18.5 g.

Figure 3d: Accession Nazino (Burkina Faso). Leaflets tapered, dark green, coriaceous. Blackish trunk little rough. Medium pods. The weight of a pod is between 3.8 and 10.5 g.

Figure 3e: Accession Kibwezi (Kenya) Short, thick leaflets. Whitish trunk, branched-down. Long and thin pods. The tree produces in 4 years on average 1.4 kg / year. The weight of a pod varies from 5 to 5.4 g.

Figure 3f: Accession TB 2 (Brazil) Leaflets dense, light green. Blackish trunk, branchy and very sarmentous. Pod relatively large, short. The tree produces on average 4.1 kg per year after 4 years of planting. The average weight of a pod is 7 g.

Figure 3g: Accession Niger 309 Leaflets long and thin, coriaceous, dark green. Reddish trunk, bushy and sarmentous. Fructification very early and abundant. After 4 years after planting, the tree can give 15 kg / year. The average weight of a pod is 7 g.

Figure 3h: Accession TV2 (Vietnam) Sweep shape, ash color, branchy. Big-short pod, scanty fruit. After 4 years after planting, the tree gives 1.1 kg / year. The weight of a pod varies from 4 to 8.2 g.

Figure 3i: Accession Kitui (Kenya) Dark green leaflets. Blackish trunk very branchy, bushy. Big pods. The weight of a pod is 4 to 10.5 g.

Figure 3j: Accession Manni (Burkina Faso) Leaflets not very dense, light green. Branchy trunk, ash color. Medium pods. The weight of a pod is 5 to 13g.

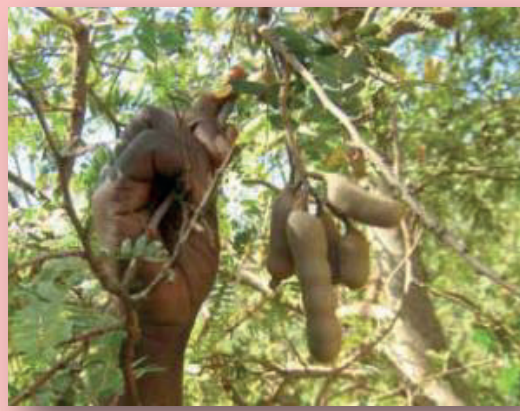

Figure 3k: Sweet tamarind (Thailand) Climbing. Small, straight pods with light green leaflets. Branchy trunk, branched, sweet pulp. The weight of a pod varies from 8.2 to 9.1 g.

Marketing tamarind products

Tamarind fruit is sold on local markets in Africa as well as on international markets. Selling it is an important source of income for farmers. For example, in Mali producers can provide up to 500 kg / year for an income of up to 84,000 FCFA/ XOF with about a selling price of dried fruit (old) at 350 FCFA / kg; and 300 FCFA / kg for dried fruits of the current year (new). Exporters can provide about 100 tons of fruit for a turnover of 14,000,000 FCFA (Kaboré et al, 2008).

In Mali, for example, artisanal units sell their processed products themselves through more or less formal distribution channels of their own (depositing / selling from fixed distributors or street retailers going door to door or sometimes on order, etc.)

The industrial units have fairly well-organized means and sales channels managed by their respective commercial departments. This is the case, for example, of some Economic Interest Groups (GIE) which, with fruit juices (based on tamarind, mango, dah, ginger) are more and more distributed in shops and "feeds" but also, ordered during various events (weddings, naming ceremonies, birthdays, etc.).

Figure 4a: Street vendor of tamarind balls (Bamako, Mali)

Figure 4b: Tamarind balls for sale in the market (Bamako, Mali)

Nevertheless, the national market remains the main place of sale of processed local agro-food products whatever the scale of production considered.

Exports in the sub region or the international market are not significant compared to the current volume and especially to the potential. It is therefore this market that must first be exploited further by acting on labeling (compliance with international standards for the export of products), availability, overall quantity and price of processed products.

In Mali, processing and selling tamarind fruit juices is important. On average, the daily quantity sold is 3,500 liters at 625 FCFA per liter (PCDA, 2005). An exporting processor can get CFAF 1,500,000 to CFAF 500,000 as income during the marketing year in 2005 for tamarind fruit (Personal communication).

Thus, tamarind tree makes an important contribution to the nutritional security and the economy of Sahelian households. However, Tamarind fruit is still harvested in Africa, unlike in Asia, where the species has benefited from extensive research efforts that have resulted in the creation of several cultivars in Thailand with a various range of products on the market.

Given these different socio-economic roles, tamarind tree has benefited from significant domestication efforts at ICRAF-WCA / Sahel to assess genetic resources and develop appropriate techniques for its growing in the Sudano-Sahelian zones of the of West Africa. Since 1997, ICRAF and its Sahelian partners have launched a major initiative to benefit from the achievements of Asian countries in tamarind tree domestication.

Since then, there has been the introduction of Brazilian and Thai accessions to the ICRAF-WCA / Sahel regional nursery in Samanko, Mali. In addition, based on the quality of the fruit (size and flavor), there was a selection of trees at sub-regional level (Burkina Faso, Kenya, Mali, Niger and Senegal). In three years (2005-2007), some forty accessions have been selected, geo-referenced and protected in a participatory manner with small farmers, national researchers and research technicians, grafted and set up in a conservation plot in Samanko, Mali (Figure 5).

This plant material (local and exotic) in collection has been grafted successfully on local rootstocks tamarind tree in Mali. The improved seedlings obtained by grafting exotic accessions on local rootstocks have flowered and fruited in 5 years, but a remarkable 1-year early arrival has been recorded with the Niger 309 accession. Compared to the taste, the Thailand tamarind tree 002 is illustrated by its specificity of being sweet. The promotion of these accessions will undoubtedly solve some food needs of the populations and will increase the profit of the processors of fruit of the species in juice by reducing production costs.

Domestication technical know-how and the promotion of village nurseries will allow a large-scale dissemination of these accessions to fight against food and nutritional insecurity, and diversify the sources of income for the populations.

Figure 5:
A planting of accessions of Tamarind Tree, Station ICRAF-Sahel, Mali

Nursery Plant Production

Preparation and conservation of the seed

The pod fruit is manually freed from the pericarp and put in warm water for 24 hours. This stay in the water makes it possible to soften the endocarp and to extract the seed by maceration. The seeds thus obtained no longer need a prior treatment before sowing. But soaking in cold or warm water for 6 to 12 hours accelerates germination by reducing latent life.

Approximately 2,000 to 2,500 seeds per kilogram of seed can be counted. A pod may contain 3 to 12 boxes each containing one seed. The seed, well dried and placed in a dry and cool place, can be kept for 3 years without losing ability to germinate.

For long-term conservation, it is recommended to keep the seed at low temperatures ranging from 4 to 5 ° C.

Preparing the substrate for nursery

The seeds respond favorably on a substrate dosed with 1 volume of well decomposed compost or manure, plus 2 volumes of sand; or 1 volume of well-decomposed park manure, plus 1 pound of compost, plus 2 volumes of sand; or a volume of good compost mixed with a volume of sand.

The species has a good development on soil with a pH ranging from 4.5 to 6.0. A phosphate fertilizer will allow rapid development of the root cap which ensures a sustainable diet of the plant. A well moistened substrate can be seeded after one to two weeks of watering, taking care to remove germinated weeds because of this moisture.

Choice of land for nursery

Preferably, a nursery should be established on a flat, well-drained surface with good exposure to the sun and protected from strong winds. The topography should have a slight slope to prevent stagnation of the water. However, we must avoid too steep slopes that impose an expensive development of the soil (terraces, drainage pits, etc.).

The nursery is a privileged place. Plants should not be produced anywhere and anyhow, otherwise it could be:

- attacked by pests, and stray domestic animals;
- damaged by negative effects of shading tall trees that do not let light through.

The choice of location is therefore extremely important. It is necessary to make a preliminary study to know precisely the conditions of the natural environment and the economic aspect to produce plants with the best success rates and the best quality / price ratio.

At the time of establishing the nursery, it is necessary to ensure:

- proximity of planting sites,
- the water supply exists,
- enough space and the number of plants to produce.

Plant production with seedling

Seeding is carried out at a rate of 1 to 2 seeds per pot, sunk to a maximum depth of 0.5 to 1 cm. Germination occurs after 5 to 10 days. Seedling can be produced by direct sowing in beds at spacing of 30 cm x 30 cm. However, direct sowing in pots is recommended in Sahelian conditions.

Monitoring and maintenance of seedlings

The thinning of potted plants takes place 2 weeks after sowing or for seedlings with at least four leaves. These thinned plants can be recovered and transplanted into other prepared pots, placed in the shade. Shading enough, without being excessive, is necessary to ensure the development of a healthy plant.

Watering must be adapted to the needs of the seedlings. A good watering, once a day, is necessary in the Sahelian zone. However, excess water that causes asphyxiation of roots and fungal diseases (yellowing of leaves, drying of twigs, etc.) must be avoided. If the seedlings are to be transplanted to fields, they must be hardened by reducing watering towards the end of their nursery stage.

Weeding is carried out as necessary while the root-pruning takes place every forty-five days until the plant is taken out of the nursery, 3-5 months after sowing. This root-pruning allows a rapid increase in diameter, thus preparing the plants for grafting. At the ICRAF Research Station in Samanko, the stems of plants grown in such conditions reach on average 1 cm in diameter and 40 cm in height after 5 month-breeding (Figure 6). This size is recommended for the production of rootstocks before grafting.

Figure 6: Tamarind seedlings, 7 months after sowing

Definition and interest of grafting

Grafting is a technique or process that involves inserting part of a plant into or on a part of another plant in such a way that they unite and grow together. The aerial part of this involvement is the graft or scion while the underground part is called rootstock or rhizome.

Grafting is a method of vegetative propagation that reproduces species that cannot easily reproduce by seed (asexual reproduction) or other vegetative propagation methods. It also makes it possible to replace the root system of a tree with a better system for: (a) better growth; (b) reduce the teenage age of a tree to mature (flowering, fruiting), in other words, reduce the period of adolescence;

(c) repair the damage to old trees or to grow young again; (d) conserve genetic characteristics for the maintenance of biological diversity.

During grafting, the plant material taken from the stem is joined in such a way that new cells resulting from wound healing eventually unite to produce new tissue that will allow the grafted plant to grow and develop normally. Other interests of grafting are:

- identical reproduction of a selected plant (clone), for a specific characteristic;
- improving the strength of the graft through the rootstock;
- exploitation of any range of soil through the different rootstocks;
- multiplication of a clone of a highly homogeneous variety.

It should be noted that grafting is the best technique recommended in the Sahel for the vegetative propagation of tamarind tree and that it is grafting by approach which is applied for the sweet cultivars of Thailand, the other types (cuttings, layering, etc.). providing less satisfactory results.

The non-grafted tamarind only bears fruits between 5 and 8 years after planting with very irregular fruiting rhythms.

It is not only characterized by low productivity, but also by poor quality fruit production. Thus, grafting is an ideal practice for shortening teenage time and increasing production through the use of more productive and higher quality accessions.

It should be noted that grafting is the best technique recommended in the Sahel for the vegetative propagation of tamarind tree.

Mother-plants and rootstocks: definitions

- A mother-plant: is a tree on which plant material (grafts, cuttings) are periodically taken for vegetative propagation purposes;
- A rootstock is a plant used to receive the graft by grafting.

Choosing and maintaining mother-plant and rootstocks

» Mother-plants

In the Sahel, the size of the mother-plant is around March, it favors the production of secondary and tertiary branches serving as grafts. The double bowl technique is used to prevent direct contact of the water with the neck of the subjects. Watering must be regular and enough. In the Sahelian zone, we offer, like most local fruit trees, 50 to 60 liters per accession per week. This rhythm is slowed down when it starts raining.

» Rootstocks

They are chosen from seedlings 6 months to 1 year old, from seed. They are selected for their strength and ability to receive a graft. The diameter at the site of the graft must be greater than or equal to that of the graft that will be implanted there. Each seedling proposed as rootstock in the Sahel requires a station with specific conditions to develop.

It must come from a variety well adapted to the environment in which the cultivars will be planted: drought-resistant on dry land, resistant to waterlogging by the water in the shallows, root deeply in the soil in the dry region, supports the salinity or the acidity in the concerned lands. Rootstocks must be well formed and healthy: stems, collar and roots straight, no signs of disease or parasitism should be detected.

Figure 7: A tamarind tree rootstock

If they are sown in pots, care should be taken to identify them in the nursery to prevent their roots from wrapping around the bottom of the bags. A regular root-pruning or the installation of the rootstocks on a stilt bed, with a vacuum at the bottom, makes it possible to overcome this handicap with the tamarind tree in the Sahel. Young seedlings 6 to 12 months old from seeds can be used as rootstocks.

Choosing and collecting the graft

Choosing grafts must be done upon farmer's choices which are criteria of flavor or size of the fruit, absence of any signs of diseases, resistance or tolerance to the attacks of plant pests and insects, precocity and the regularity of fruiting.

Grafts or scions must be taken from the top of the accessions or mother-plants. It is the already-aged twigs that are best suited. The twigs selected for graft harvesting should be vigorous; there should be no signs of parasitism. They are taken from the periphery of the crown rather than inside. The presence of lateral or terminal buds is checked. They must be active, but not burst (Figures 8a and 8b).

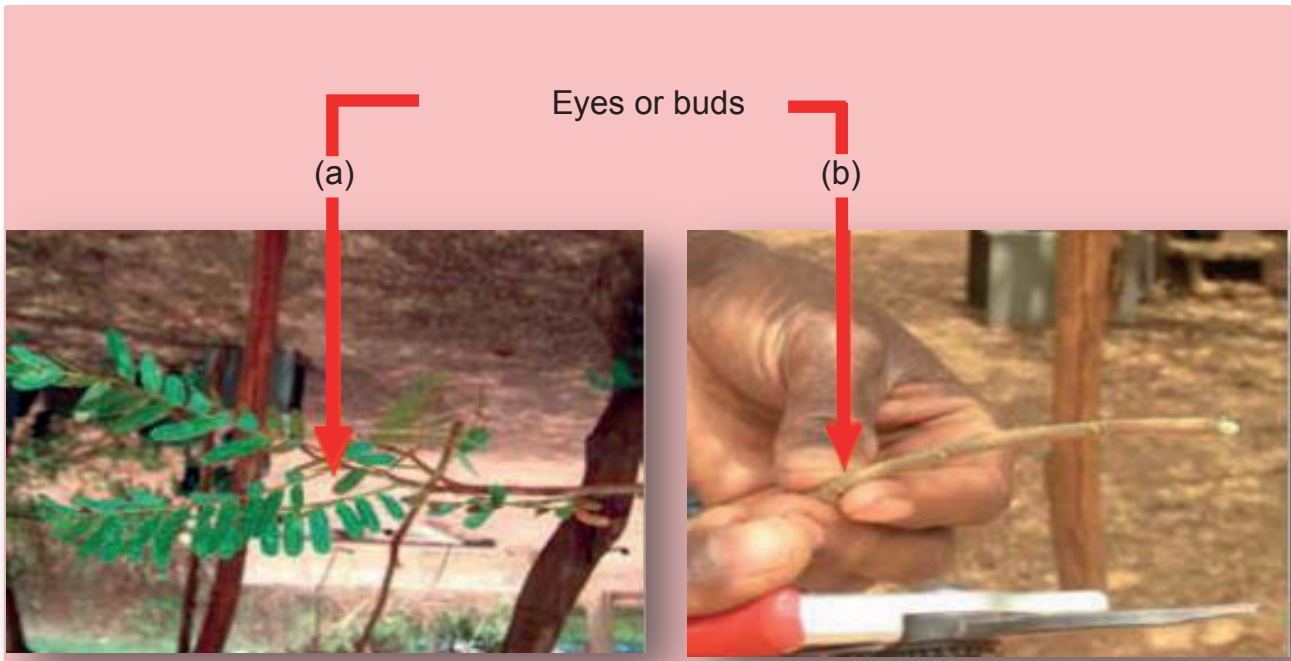

Figure 8a : Branch with grafts

Figure 8b : A graft collected with flower buds

A bud burst is a bud that has already started growing. A dormant bud is one that shows no activity. The ideal, for the collection of the patches or grafts, is that the bud is very slightly inflated (which proves that it is not dormant), but not burst (which makes the handling risked).

To activate dormant buds, selected branches may be stripped nine (9) days prior to collection of patches or grafts.

Grafting

Different types of grafting

Three (3) methods were found suitable for tamarind grafting in the Sahel (success rate: 80-90%). Those are:

- single slot grafting,
- sapwood grafting,
- approach grafting.

However, for sweet tamarind, only approach grafting is used for its multiplication, with 85 to 95% success, the other methods reaching barely 5% (Personal communication).

Single slot grafting

Period

The best time for single slot grafting is in the high sap period (March to June). For single slot grafting in the Sahel, grafting should be avoided in early September as there is excessive flow of sap from nicks on the rootstock. To prevent the transplant from drowning, it is advisable to prune the subject a few days before, slightly above the planned grafting point. Thus, tears or sap can be brought before by grafting a few centimeters lower.

Subjects and grafts

The subject must have a diameter greater than or equal to that of the graft, must be slightly knotty and vigorous enough; the branch-graft should be mature and well lignified, having 3 to 5 nodes (Figures 8a and 8b).

Procedure

The graft, about 10 cm long with 3 to 5 knots (eyes or buds), is cut at its base in double bevel (Figures 9 to 17) starting the bevels at the level of the lower eye, either normally or laterally so that it has a thicker side (one that carries the lower eye and will be placed towards the outside of the rootstock) than the other (placed towards the inside of the rootstock).

Figure 9 : Collecting the tamarind tree graft

Figure 10 : Sizing tamarind tree graft

Figure 11 : Opening slot on the rootstock

Figure 12 : Bevel graft size

Figure 13 : Inserting the graft into the rootstock slot

Figure 14 : Bandage of the incised part of the new subject

Figure 15 : End of new subject bandage

Figure 16 : Total recovery (formwork) of the new subject

Figure 17 : End of procedure with identification label

The graft is then introduced into the slot, by adjusting it at least at one of its ends, in order to make the generating zones (cambia) of the graft and the rootstock agree. It is advisable to slightly tilt the graft relative to the rootstock to ensure at least one-point match; it is however preferable to make the generating zones coincide for a greater possible length by arranging the graft in a good place and parallel to the axis of the rootstock. (Figure 13).

It is necessary to cover the graft securely with an aluminum foil pad that provides lower temperatures for the device, in addition to the clear plastic and / or only with clear plastic for at least two weeks. Then carefully cover with the grafting mastic or tie with plastic cut into strips all exposed tissue parts (Figure 16). It should be noted that the plastic cover protects the graft against drying out, penetration of water and dust between wounds.

Advantages from single slot grafting

Advantages from single slot grafting are:

- an easy and accessible technique because it is similar to mango grafting and citrus already popular in rural areas;
- Performed throughout the year except during the vegetative rest period of plants (December-February) when the graft must wait for the vegetative awakening to start. However, the graft must be fully protected from cold and wind.

Grafting Approach

The best period for grafting approach is from March to October.

Procedure

Unlike other techniques, grafting approach does not involve graft collection. It only requires moving the young rootstock from the nursery to the mother-tree that is to be propagated. On the subject and on the graft, superficial wounds of 3 to 4 cm in length are penetrated to the sapwood they expose;

then, the two wounds are applied against each other so that they coincide over their entire surface or simply on one side if the diameter of the rootstock is substantially greater than that of the graft; we ligate thereafter.

The different stages of grafting approach are illustrated in Figures 18 to 23. The young plants must sometimes be raised in pots to be able to bring them close to the stock plants, flush with the soil or by scaffolding at the right time.

Advantages from grafting approach

Grafting approach:

- helps to circumvent the phenomena of incompatibility between graft and rootstock;
- also offers opportunity for success when other grafting techniques prove difficult in practice.

The constraints relating to approach grafting are: a) plants are very bulky; (b) weaning period is long; (c) weaning must be gradual.

Figure18: Scaffolding at the nursery ICRAF-WCA/Sahel

Figure 19: Wound provocation on the rootstock and a branch of parent-plant

Figure 20: Contacting the wounds caused

Figure 21: Adjustment of one or both sides of the rootstock to those of the incised branch

Figure 22 : Tying up the two incised parts (bandage)

Figure 23 : Coverage of the bandaged parts up to the separation level of rootstock end portion to the parent-plant

Tools for grafting tamarind tree

Like any grafting, tooling is an essential factor in the success of operations. The required equipment for grafting is provided below (Figure 24).

All of these tools and materials can be called 'grafting kit'. It's about:

Figure 24 : Essential Equipment for grafting

- knives for grafting or budding (budding knives or pruning knives) of good quality and well sharpened. Budding knives have a curved blade and a beak that allows lifting the bark tongue for the T-graft;
- fine-textured sharpening stone for sharpening grafting and budding knives shingles;
- alcohol 90 ° C (or 70 ° C) to disinfect tools;
- Pruning shears, sprays and plastic bags to collect grafts;
- icebox and ice packs to keep grafts cool for a few hours or days;
- material of dressings types for grafting or budding (strips of polyethylene, raffia, rubber bands, adhesive tapes, biodegradable ribbons) about 1 cm wide;
- graft wax or white latex paint to cover the graft and prevent the drying of tissue after grafting;
- small bags or strips of transparent polyethylene to cover the upper part of grafts and fine string;
- identification labels;
- box of drugs and dressings to heal possible wounds with grafting;
- indelible ink writing case.

Disadvantages common to grafting

Among disadvantages relating to grafting through different types or modes we can highlight:

- transmission of viral and bacterial diseases by grafts or grafting knives, if it is not properly disinfected and cleaned after each operation with a mixture of water and bleach;
- identical reproduction of mother-plant (genotype), not favoring the diversification of the genetic characters, unlike the multiplication through seeds.

Graft Maintenance

A graft should be protected from clumsy movement before recovery. It will then be necessary to ensure a sustained maintenance of the future graft by ensuring a regular and sufficient watering as well as a regular weeding. The appearance of discharges, re-growths or greedy under the attachment area of the graft / rootstock makes uncertain the recovery of the graft. We must consider removing them at each appearance with pruning shears, which promotes the resumption of graft.

Labeling and identifying grafts are very important steps in the collection in order not to make an error of confusion between different accessions from the same source or from a source in a nursery, in a future gene bank or in an orchard with clones. The protection of grafts against animals is imperative. Indeed, in the irrigation system, tamarind plants permanently carry green leaves that can serve as a possible transitional shelter for certain pests or attract animals in rambling.

Setting up fruit orchards

Ecological and cultural requirements

The tamarind tree is suitable for well-drained alluvial soils, with an average rainfall of 250 to 1200 mm per year. It can be found at altitudes between 0 and 1600 m above sea level (Muok and Alem, 2011). In dry areas, the species thrives along streams.

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Fruit orchard establishment

Holes digging

One month prior to planting the tamarind tree, the farmer must prepare holes and fill them with potting soil and compost manure or well-decomposed compost at a rate of 1.5 kg per hole and with 0.2 kg of phosphate rock, added to a dose of termiticide to limit termite damage. A large hole is always preferable (at least 60 cm x 60 cm x 60 cm). This allows the seedlings to have a very fast initial growth and then to obtain a good fruiting.

Spacing

Spacing varies according to climatic conditions and selected tamarind accessions. Optimum spacing is 10 mx 10 m, or 100 trees per hectare (Niger 309, TB 1, TB 2, TV 2). However, it is advisable to use large spacings of 15 mx 15 m, or even 20 mx 20 m for large accessions with large crowns such as sweet Thailand and Kitui (Kenya) in case the plants are associated with crops such as sorghum, millet, maize, etc. Typically, Kibwezi accessions from Kenya and Nazino from Burkina Faso are small but have large sizes.

Maintenance of plants

Watering young trees

The water supply from the first year promotes the recovery of young plants. Although it is not practiced very frequently during the dry season, watering should be done thoroughly at least twice a week.

Irrigating mature trees

The recovery assured, irrigating tamarind trees is necessary or optional according to the intended aims, the site and the mode of cultivation adopted (intensive or extensive fruit production).

In general, the large size of fruit trees has a big impact on the amount of water used. Water supply can be from a permanent watercourse or by digging a well in or near the plot.

The amount of water used per tree and the frequency of watering depend on the physical properties of the soil, climatic conditions (potential evapo-transpiration) as well as the stage of development of the plant. However, water supply should not inhibit fruiting because too much watering can promote vegetative development at the expense of fruit production. Normally, irrigation

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should be interrupted (at least one month) during the flowering period so that the water stress caused can provide better flowering. The base of the trunk should be protected from water by a double bowl to prevent immersion of the lower part of the stem of tamarind favors the occurrence of fungal diseases such as gummosis.

Maintenance fertilizer

To compensate for nutrient removal and accelerate tree growth and productivity in biomass, especially fruit, quality animal manure and fertilizers and soil improvers can be applied. The fertilizers generally brought are: phosphorus, potash or ashes and calcium.

Application of an organic or chemical fertilizer makes it possible to put at the disposal of the plant the nutritive elements which it needs. In the Sahelian area, farmers are advised to use organic manure, which is easier to obtain. In practice, it is advisable for a tamarind plant (Kalinganire et al., 2007):

- 100 to 200 g of urea per tree after planting and at the end of the rainy season,
- 500 g per manure tree based on nitrogen and potassium at the beginning of fruiting,
- 2 to 3 kg of NPK compound fertilizer per fruit tree.

The fertilizers generally brought are: phosphorus, potash or ashes and calcium.

Size and maintenance

One of the most beneficial operations in the maintenance of a tamarind plantation is its size, the purpose of which is to facilitate the harvest and at the same time to provide the necessary care for the tree. In fact, size gives the tree a good shape that makes harvesting easier and at the same time it eliminates deformed, broken, dead branches or diseased parts, thus allowing the development of healthy and vigorous secondary and tertiary branches as well as the rejuvenation of the tree to produce attractive large fruits.

It is easy to harvest tamarind fruit when the trees are short. For this, it is desirable to cut them to 2 to 3 m high. The main stem is cut between 1 to 2 m above the first 2 to 5 secondary branches. The side branches will take over and form frames to support the fruits. The twigs of the tamarind tree come into fruiting from the 2nd year. It is therefore not wise, with the approach of wintering in the Sahel (May, June), to clear all the trees and it is advisable to think of sprinkling the wound of the sizes with an antiperspirant mixed with a fungicide (Carbatène, Thirame, Mancozebe, etc.).

Protection of plants against animals

Domestic and wild animals can cause serious damage to young trees even on those that are planted. Building a fence (preferably a hedge) around the farm can help address this problem.

Other maintenance

Other activities such as weeding, and mulching are important because they reduce herb competition and create a sufficiently moist and nutrient-rich environment following mulch decomposition.

One of the most beneficial operations in the maintenance of a tamarind plantation is the size, the purpose of which is to facilitate the harvest and at the same time to provide the necessary care for the tree.

During the first years after the tamarind plant, you can take advantage of the wide spacing between the trees to make an annual crop until the main crop - the tamarind - takes up all the available space.

Plants such as legumes, vegetables, tarot, eggplant, cover crops, etc., are potential crops associated with tamarind tree.

Protection against diseases and pests

Like all fruit plants, tamarind tree is also attacked by pests (squirrels, parrots, bats, insect larvae, etc.) and diseases that can cause serious damage to plants. In the Sahel, symptoms leading to the death of the plant have been reported.

Preventive measures to control such attacks are better than curative measures (Kalinganire et al, 2007). However, during severe attacks, the horticulturist must resort to curative measures and in extreme cases; the entire plant can be destroyed, thus avoiding the risk of spreading the disease. Preventive measures include:

- use of a good multiplication material,
- enough supply of the plantation in water and manure,
- use of clean equipment during sizing operations,
- destruction of the whole plant or part of the plant showing signs of disease.

Birds and bats also feed on tamarind fruit at ripening. As a means of struggle, we recommend the following measures:

- cover the entire tree with a large medium horticultural net or scarecrow;
- periodic spraying of the plant with a solution of leaf extract and the Neem fruit, *Azadirachta indica* ;
- Caretaking, etc.

Useful Recommendations

- When it is not possible to plant the plants in a timely manner, it is best to cut the taproot of the plant and reduce the foliage to avoid deep root development.
- Availability of highly productive accessions and control of grafting by farmers can help promote plant production.
- A market study is needed at the local and / or regional level before guiding producers to a large production without knowing beforehand if their products will be sold.

Market opportunities are however available; what is needed is an analysis of the international market by the local and / or regional managers and a guarantee of a good quality product (by farmers) in order to satisfy the ever increasing but competitive market.

A market study is needed at the local and / or regional level before guiding producers to a large production without knowing beforehand if their products will be sold.

Overall conclusion

At what time of the year should a tamarind cultivar or accession be grafted? How to get a graft? How to choose a rootstock? Each of these questions is answered in this well-illustrated technical sheet. It delivers simple and easy methods that will guide step by step each of your handlings.

Also, a molecular analysis of genetic diversity has shown that populations in East and West Africa are different. Among the 10 populations tested (Burkina Faso, Cameroon, Guadeloupe, India, Kenya, Madagascar, Reunion, Senegal, Tanzania, and Thailand), it is that of Cameroon which presented the greatest diversity (Muok and Alem, 2011). Relatively large genetic diversity was found throughout the species' range, indicating that there would be no immediate concern for genetic erosion as long as conditions allow for regeneration of young plants.

It should be noted, however, that farmers select trees based on the taste and size of tamarind fruit and other socio-economic characteristics, such as market value. Given the complex interconnectedness of the components of the trading systems, it will not be surprising that multidisciplinary approaches are used to study periodic markets. Carol Smith's anthropology work in the periodical markets is particularly noteworthy in this respect since it has combined geographical and anthropological approaches to achieve them (Smith, 1975, 1976, 1985).

From the point of view of timeliness and production, the Niger 309 accession was clearly illustrated (1 year and 15 kg of pods at 4 years) followed by the accession of Nazino (Burkina Faso) with only 6.4 kg of pods. The record for the average weight of a pod is held by the accession Niger 305, which is also characterized by an early fall of the leaves (18 g against 13 g for the accession Manni and 10 g for the accession Nazino of Burkina Faso). From all tamarind accessions at the station in the ICRAF-WCA / Sahel conservation plot, Kodiéna (Burkina Faso) is the most acidic, followed by Kenya's KTN 2 accession.

Reproduction by cuttings and by grafting sweet tamarind accessions in the collection was quickly controlled by the Sahelian peasants. These accessions have exceptional qualities:

- plants are easy to prune;
- fruits are early, abundant, large, sweet and resistant to certain pests.

Planting these tamarind accessions from grafting could improve sustained and profitable production in Sahelian rural communities.

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