

# Growing Jujube Trees: A handbook for the Sahelian Horticulturist

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WORLD AGROFORESTRY CENTRE (ICRAF)

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# Foreword

As part of the 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.

Thus, in collaboration with the institutes for research 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 of different agroforestry species were carried out including growing jujube tree *Ziziphus mauritiana* Lam. Improved jujube cultivars with a high content of various nutrients (vitamins C and A, carotene, calcium and magnesium) have been successfully introduced from India and Thailand. These cultivars flower and grow six months after grafting (two to three years for the local variety) and produce much larger fruits (over 25 grams) than the local variety (less than 2 grams).

This document mainly discusses jujube growing techniques and more specifically those of the grafting of this species. These techniques make it possible to increase the yields of jujube production to the producers, through the use of a more productive plant material and a good management of the tree.

It is desired that users of this manual provide feedback to the ICRAF-WCA / Sahel team for the improvement of this document for future editions.

Thus, this document can contribute to the increase of the production of the jujube tree and more specifically to the reduction of the poverty of the rural poor communities of the Sahel.

**Bréhima Koné, Antoine Kalinganire and Modibo Doumbia**



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# Acronyms and Abbreviation

<b>AFEE</b>	Women's Association for Education and the Environment
<b>ANAFE:</b>	African Network for Agriculture, Agroforestry and Natural Resources Education
<b>CAFO:</b>	Coordination of Women's Associations and NGOs
<b>CMDT:</b>	Malian Company for Textile Development
<b>CRA:</b>	Regional Chamber for Agriculture
<b>CREDO:</b>	Network of collaboration between Non-Governmental Organizations, Farmers Organizations, technical services, research institutes and development partners
<b>DRAMR:</b>	Regional Department of Support to the Rural Communities
<b>ENCR:</b>	National School for Rural Managers
<b>ENSAH:</b>	National School for Applied Sciences
<b>FAO Mali:</b>	United Nations Fund for Food and Agriculture, Mali
<b>FCIM :</b>	Filles du Cœur Immaculé de Marie, Kati
<b>ICRAF-WCA:</b>	World Agroforestry Centre – West and Central Africa
<b>IDR:</b>	Institute for Rural Development
<b>IER:</b>	Institute for Rural Economy
<b>INERA:</b>	Institute for Environment and Agricultural Research
<b>INRAN:</b>	National Institute for Agronomic Research in Niger
<b>IPDR:</b>	Polytechnic Institute for Rural Development
<b>IPR/IFRA:</b>	Rural Polytechnic Institute / Institute for Training and Applied Research of Katibougou
<b>ISRA:</b>	Senegalese Institute for Agronomic Research
<b>OHVN:</b>	Office for the High Valleys of Niger
<b>ONG:</b>	Non-Governmental Organization
<b>OP:</b>	Farmer Organizations
<b>ORS:</b>	Office Riz Ségou

<b>PAE:</b>	Agro Ecological Project
<b>PAGEEM:</b>	Expansion of the Support Program for Environmental Education in Mali
<b>PISA Nara:</b>	Integrated Project for Food Security in Nara Lag Nara Project: Development Project in Nara
<b>Projet USC Canada:</b>	Canadian Unit and Services
<b>UCAD:</b>	Université Cheick Anta Diop, Dakar
<b>UN:</b>	United Nations
<b>WVI:</b>	World Vision International

# General Introduction

## Species and its use

The jujube tree (*Ziziphus mauritiana* Lam.) is an indigenous fruit species. It is found spontaneously in the Sudanese and Sahelian zones of Burkina Faso, Cameroon, the Gambia, Guinea, Mali, Niger and Senegal. The species is widely distributed in Africa and tropical South Asia: India, Pakistan, Bangladesh, Sri Lanka.

A multi-purpose species, it is one of the priority species in the ICRAF-WCA / Sahel program. The species is still in the wild, except for a few cultivars from India and Thailand, introduced recently in Sahelian village fields.

Wild fruit, the jujube tree is used in traditional medicines and in food for populations.

The roots, administered as a decoction, are a very effective tetifuge; but if ingested in high

doses, the decoction could become toxic. Bark and leaves are used in various medicinal preparations:

Hemorrhages after childbirth and against phagedenic ulcers, hemorrhoids, diarrhea, vomiting, stomachaches, wounds. The twigs are anti-cancerous. Their use fights amenorrhea. It is a woody species well known to the Sahelian and Sudano-Sahelian farmers. It provides people with non-wood products such as fresh or dried fruit, either directly or in the form of a pancake. The fruits are used against rickets, anorexia, kwashiorkor, scurvy. Curdled milk with fruit pulp, mixed with rice, combats anorexia.

The fruit is the main benefit of the jujube, widely consumed by people and being the subject of an active trade involving mostly women. It is a drupe whose pulp is very rich in vitamins A and C, in phosphorus, in proteins and rich in mineral salts. The fruit of the local variety is small and the pulp sometimes not very sweet. The fruit can be transformed into flour for various food uses: dough, cake, drinks, porridge. The leaves constitute aerial forage very well appreciated by the Sahel livestock keepers and pastoralists. Jujube is also widely used as crop protection hedge, effective and uncompetitive. Termite-resistant wood is used for making tool handles and yokes. It is also a good heated wood and it produces good quality coal.

This manual has been developed to present growing techniques of jujube with an emphasis on the technique of its grafting, this to improve its production in the Sahel. The document is intended for arborists, field technicians in charge of adopting agroforestry technologies and nursery growers who are actively involved in the dissemination of jujube. In addition, the book was developed to support the practical training of producers on jujube growing in the Sahel.

The jujube is used in traditional medicines and food for populations.

## Summary description of jujube

**Scientific name:** *Ziziphus mauritiana* Lam; French name: jujubier; English name : ber and Indian jujube.

**Local names:** n'tomon (bambara); tômônnon (malinké); diabè (fulfude); Magaria (songhaï) ; magunuga (moré) ; ngit (sérère) ; ajzen (tamachek) ; dem (wolof).

**Synonyms :** *Ziziphus jujuba* (L) Lam., *Z. jujuba* (L) Gaertn. (including var. *Stenocarpa* Kuntze and var. *aequilatrifolia* Engl.), *Z. tomentosa* Poir., *Z. rotundata* D.C., *Z. aucheri* Boiss., *Z. insularis* Smith, *Z. sororia* Roem. And Schult., *Z. orbocantha* D.C

Jujube belongs to the genus *Ziziphus*, family Rhamnaceae and order Rhamnales. It is described as a thorny and shrubby shrub, a bush or small tree 3-4 to 10-16 m tall (trees of 20 m are very rare), with rounded crowns with drooping branches. The bark is gray to brown, slightly fissured, with pink to red slice. Branches are tomentose, whitish, zigzag. The spines are arranged in pairs at the axils of the leaves: one, more or less straight and effective, a little upwards, reaches 1.8 cm long; the other hook, rather downward, is a little shorter. The leaves are alternate, highly variable, elliptical, ovate or suborbicular (Figure 1), 1.3-7 × 1-4 cm, with a finely castellated margin, rounded and mucronate, rounded or subcordate, symmetrical or almost; limb green and more or less shiny above (upper side), greyish and pubescent below (lower side). The pubescent petiole is 0.5-1.2 cm long. The vein webbed at the base has three elements; the two outer ribs each carrying 7-10 slightly protruding tertiary ribs are arcuate and more or less parallel.

Figure 1: Branch, leaves and graft of a jujube tree.



The inflorescence, in tomentose or woolly fascicle of 3-8 flowers, arranged at the axils of the leaves, is 2-4 cm wide. The flower is pedicellate (1-3 mm long), yellowish, 3-4 mm in diameter, with a calyx more or less tomentose with 5 teeth, a corolla with 5 petals. The flower is characterized by stamens opposite petals. The stamens are in a spiral of bisexual and actinomorphic flowers. The lobes of the calyx are very small, the calyx is whole. An intra-staminal disc is often well developed. The fruit is a globose drupe, glabrous, 1.2-1.5 cm in diameter, brownish or purple when ripe and containing a large nucleus enveloped in a whitish pulp more or less floury.

The jujube tree is seasonal. The flowering takes place rather at the end of the dry season, more precisely around May with the introduced accessions from Senegal and those introduced from Thailand.

The preferred habitat of the jujube tree is the Sahelo-Sudanian savannas to Sudanese, on cultivated land, on sandy or rocky soils, on the edges of ponds or wadis. It is very common in the Sahel and widely disseminated.

### **Accessions introduced in the Sahel**

In order to increase jujube production in the Sahel, the World Agroforestry Centre (ICRAF) and its partners have introduced new accessions in the Sahelian area from Brazil, India and Thailand. Most of these accessions (Gola, Umran, Kaithli, ICRAF 8, Sotubata, etc. are distributed in farmland, the rest being observed on-station. Their vegetative characteristics as well as the estimated fruit production per tree are described in Figures 2a-2r. However, the number of fruits per kilogram varies from season to season. Marketing jujube products

In order to increase jujube production in the Sahel, the World Agroforestry Centre (ICRAF) and its partners have introduced new accessions in the Sahelian area.

### **Marketing jujube products**

Local fruits are actively traded in the sub-region. The main use of jujube tree is the pulp of the fruit, consumed fresh or in dry, and used to produce juice. The Sahelian potentialities are mainly the sale of juice, fresh fruits and dried fruits. In 2007, the selling price of fresh fruit in Bamako was about 350 FCFA per kg.





Figure 2a: Local jujube tree (Senegal). Spherical fruit, small, 5-8 mm in diameter. The branches are tomentose, sometimes with leafless ends, but with thorns.

The tree, after 3 years of planting, produces an average of 7kg of fruit per year. One kilo (1kg) contains 1970 fruits.



Figure 2c: Kaithli (Ex-India). The leaf is oblong, the end of the style is round; the end of the leaf can also be acute.

One kilo (1kg) contains 24-27 fruits. The tree produces 18 to 23 kg after 3 years after planting.



Figure 2e: ICRAF 07 (Ex-Thailand). The shape of the tree is semi straight, the oblong fruits, the oval leaves, the end of the obliquely pointed style. One kilo (1kg) contains 28 fruits. The tree produces 25 kg of fruit on average per year.



Figure 2b: Sotubata (Ex-India). Oblong leaves, end of the round style. One kilo (1kg) contains 25 fruits. The tree, after 3 years of planting, produces an average of 28 kg of fruit per year.



Figure 2d: Umran (Ex-India). Oval leaf, end of round style, end of subacute leaf. One kilo (1kg) contains 24 to 25 fruits.

The tree produces an average of 21 kg of fruit a year, 3 years after planting in the Sahel.



Figure 2f: ICRAF 04 (Ex-Thailand). The end of the style is round, the end of the subacute leaf. The cavity of the pulp is the same at both ends. One kilo (1kg) contains 32 fruits. The fruiting of the tree is very dense. A tree can carry an average of 30 kg per year.





Figure 2g: ICRAF 09 (Ex-Thailand).

The end of the style is downright tapered, that of the leaf is sub-acute. The base of the leaf is wide. One kilo (1kg) contains 13 to 17 fruits. The tree carries an average of 36 kg of fruit per year.



Figure 2h: ICRAF 08 (Ex-Thailand). Scattered-shaped tree, oblong fruit, oval leaf, end of round style with depression. One kilo (1kg) contains 16 fruits. The tree produces an average of 38 kg of fruit per year in the Sahel.



Figure 2i: ICRAF 06 (Ex-Thailand). Obovate fruit, oblong leaf, tip of flat style with depression, end of subacute leaf, cavity of pulp absent. One kilo (1kg) contains 14 to 20-22 fruits. The tree produces on average 40 kg of fruit per year, 2 years after planting.



Figure 2j: ICRAF 02 (Ex-Thailand). Oblong leaf, end of the round style, while that of the leaf is acute. One kilo (1kg) contains 36 fruits. The tree produces at most 27 kg of fruit on average per year and per tree after 3 years after planting.



Figure 2k: ICRAF 05 (Ex-Thailand).

The end of the style is round with a low depression, the end of the leaf is subacute, the cavity of the pulp is end to end. The base of the leaf is wide. One kilo (1kg) contains 28 fruits; the tree produces an average of 30 kg per year.



Figure 2l: ICRAF 03 (Ex-Thailand). The end of the style is obliquely stitched, that of the sub-acute leaf. The cavity of the pulp ends both ends of the fruit; the base of the leaf is wide. One kilo (1kg) contains 30 fruits; the tree produces an average of 30 kg per year.



Figure 2m: ICRAF 01 (Ex-Thailand). Oblong fruit, oval leaves, obliquely hooked style. One kilo (1kg) contains 37 fruits. The tree produced per season 28 kg of fruits on average per tree, 3 years after planting.



Figure 2o: Ben Gourion (Ex-India). The leaf is oblong. The end of the style is crooked and oblique. One kilo (1kg) contains 23 fruits. The tree produces an average of 24 kg at the age of 3.



Figure 2q: Seb (Ex-India). The shape of the tree is straight, the round fruit, the oval leaf. The end of the style is as flat as the depression of an apple. One kilo (1kg) contains 36 fruits. At three years of planting, the tree produces an average of 43kg of fruit a year. In the Sudanian area, the fruit has cracks.

Figure 2n: Gola Ex-India). Fruit is round, leaf-shaped or oblong. One kilo (1kg) contains 22 fruits. Three years after planting, the tree produces an average of 26 kg of fruit per year. In irrigation condition, the tree does not seem to stop to fructify during the year.

Figure 2p: Local jujube tree (Niger). The shape of the tree is semi straight, the round fruit, the oval leaf, the end of the obliquely pointed style. The dominance of the hull is perceptible compared to the pulp. One kilo (1kg) contains 156-160 fruits. Its rapid growth is very remarkable. The tree produces an average of 10 kg of fruit at the age of 3.



Figure 2r: Local Jujube tree accession (Kaya, Mali). Flowering and fruiting are exuberant. The shape of the tree is straight, the fruit round, the oblong leaf. The end of the style is as flat as the depression of an apple. One kilo (1kg) contains 158 fruits. The tree produces on average 8 kg of fruit per year at the age of 3.

The benefits for women in processing and exporting jujube fruit cake are important. On average, the net daily income amounts to 2 500 FCFA for a processor. An exporting woman can raise CFAF 350,000 to CFAF 500,000 as income during the jujube marketing campaign. A farmer in Segou (Mali) recorded an income of over 3 million FCA in 2007 on a plantation of about 2 ha. Thus, the jujube tree makes an important contribution to the nutritional security and the economy of the Sahelian households. However, the fruits of the jujube remain picking products, unlike in Asia where jujube has benefited from important research efforts that have allowed the creation of several cultivars in China, India and Thailand with a range of diversified products on the market.

Given these different socio-economic roles, at ICRAF-WCA / Sahel, jujube tree has benefited from significant domestication efforts to evaluate genetic resources and develop appropriate techniques for its growing in the Sudano-Sahelian areas of the Sahel in West Africa. Since 1997, ICRAF and its Sahelian partners have launched a major initiative to benefit from the achievements of Asian countries in the domestication of *Z. mauritiana*. Since then, there has been the introduction of Indian and Thai cultivars at 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 the sub-region level (Burkina Faso, Mali, Niger and Senegal). Over three years (2005-2007), about sixty trees were selected in a participatory manner with small farmers, national researchers and research technicians, grafted and set up in a conservation plot in Samanko, Mali. In addition, these trees have been geo-referenced and protected by farmers and landowners.

This plant material (local and exotic) in collection was successfully grafted on rootstocks of following *Ziziphus* species: *Z. abyssinica* (Hochst), *Z. amphibia* (A. Chev), *Z. mauritiana* (Lam), *Z. mucronata* (Willd) and *Z. rotundifolia* (Roth) Lam. The transplanted plants of all cultivars improved with all the rootstocks flowered and fructified with remarkable precocity, 6 months after grafting. Plants, especially exotic cultivars, also produced fruits 25 larger than the fruits of unimproved local individuals. In particular, vegetative expansion and grafting were one of the important steps in introducing these new cultivars.

In addition, controlling biology of sexual reproduction and the technique of controlled pollination make it possible to create intra-specific hybrids more adapted to the Sudano-Sahelian conditions.

# Plants Production in nursery

## **Seed preparation and conservation**

Crushing breaks the endocarp, the hard shell of the kernel and extracting the almond. The seeds (almonds) thus obtained do not need a prior treatment. In Mali, there are about 39,000 to 42,500 seeds per kilogram. The endocarp normally comprises two boxes each containing a seed. The seed, well dried and stored in a cool, dry place, can be stored for two (2) years without loss of germinability. For long-term storage, it is recommended to keep the seed at low temperatures ranging from 4 to 5 ° C.

The endocarp is crushed between two stones. A strict sorting makes it possible to separate the well-conforming seeds from the broken pieces.

## **Preparing the substrate for the nursery**

Seedlings 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 (PNT: Tilemsi Natural Phosphate) allows rapid development of the root cap which ensures a sustainable diet of the plant. A well moistened substrate can receive seedling after one to two weeks of watering, taking care to remove germinated weeds with this moisture.

## **Selecting land for nursery**

### **Nursery**

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 takes place within 72 hours. Production can be carried out by direct sowing in beds at 30 cm × 30 cm spacings. However, direct sowing in pots is recommended in Sahelian conditions.

### Monitoring and maintenance of seedlings

The removal of potted plants takes place two (2) weeks after sowing or with four (4) leaves. These thinned out plants can be recovered and grafted into other prepared pots, placed in the shade. Sufficient shading, without being excessive, is necessary to ensure the development of a healthy plant.

Watering must be adapted to the needs of the seedlings. A sufficient watering, once a day, is necessary in the Sahelian area. However, avoid excess water that causes asphyxiation of roots and fungal diseases. If the seedlings are to be transplanted to fields, they must be hardened by reducing watering towards the end of their nursery period.

Weeding is carried out as necessary while the ringing is carried out every month until plants are out of nursery, 4-6 months after sowing. This ringing allows a rapid increase in diameter, preparing the plants and grafting. At the ICRAF Research Station in Samanko, plants grown under these conditions reach a diameter of 1 cm, and a height of 40 cm after 5 months of rearing (Figure 3). This size is suitable to produce rootstocks.



Figure 3. Size of a jujube tree in a nursery, 6 months after sowing.

# Vegetative multiplication: grafting jujube tree

Grafting was the best method for vegetative jujube growth in the Sahel. This is the method recommended to the Sahelian horticulturist for the production of seedlings and the establishment of jujube nursery.

Grafting is the method that has given the best results for jujube vegetative propagation in the Sahel.

## Definition and interest of grafting

Grafting is a technique of bringing together two pieces of living plant material so that they can unite and form a new, well-formed plant. If the stem of the plant is a single bud, then this called budding. In other words, the grafting consists in uniting one or more fragments of a plant that one wishes to reproduce on a plant of the same species or a similar species, in order to obtain a new individual. The technique makes it possible to produce plants identical to the mother-tree.

Grafting is a method of vegetative multiplication that allows the expansion of species that cannot easily be reproduced by seeds (sexual reproduction) or other reproductive methods by vegetative expansion. The grafting also makes it possible to replace the root system of a tree by a better system for a better growth; to shorten the time needed for a tree to mature (flowering, fruiting), in other words, reduce the period of adolescence; to repair damage to older trees or to rejuvenate them.

During grafting, the plant material taken from the stem is joined in such a way that the new cells resulting from wound healing eventually unite to produce new tissue that will allow the transplant plant to grow and develop normally. Before grafting, it must be ensured that the plant material that we want to unite is compatible and above all, we must consider their physiological age. The success of the operation will also depend on many other factors, namely: moisture, temperature, contact area between rootstock and graft, hygiene measures and plant material integrity. Graft is an aerial part taken from the tree containing the dormant buds that are to be propagated and that form the crown of the new plant. The rootstock is the lower part that provides the root system of the new plant.



.... grafting is an ideal practice for increasing production through the use of more productive accessions

The local jujube fruiting only 24 months after planting with very irregular fruiting rhythms. It is not only characterized by low productivity, but also by poor quality fruit production. Note that the pulp represents 1% of the weight of the fruit. Thus, grafting is an ideal practice for increasing production through the use of more productive accessions. Moreover, it should be noted that grafting is the best technique recommended in the Sahel for the vegetative expansion of jujube, the cuttings giving less satisfactory results. Selection and maintenance of mother-trees and rootstocks

## **Mother-trees**

Sites for the mother-trees used for the collection of grafts must be well maintained. The production pruning period is around the month of March. The double bowl technique prevents direct contact of the water and base of the subjects. Watering in this period quickly induces the bud burst of jujube that can be grafted around June. It must be frequent and sufficient. In the Sahelian zone, we offer 50 to 60 liters / per accession and per week. This rhythm is slowed down when the rains settle.

## **Rootstocks**

The rootstock should be selected from a young seedling from 6 months to 1 year old. It is selected for its strength and ability to be grafted. The diameter at the site of the graft is greater than or equal to that of the graft that will be implanted there. Each of the species proposed as rootstock in the Sahel requires a particular type of station with specific conditions for development. They belong to a variety that is well adapted to the environment in which the cultivars are to be planted: drought-resistant on dry land, resistant to waterlogging in the shallows, deeply rooted in the soil, dry soil, supports salinity or acidity in the land concerned. The proposed rootstocks are well formed and healthy: stems, collars and roots are straight; no signs of disease or parasitism should be detected. If they are sown in pots, care should be taken to graft them to the nursery to prevent their roots from wrapping around the bottom of the bags. A regular ringing 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 jujube trees in the Sahel.

## Selecting and collecting the graft

Grafts or scions are taken from the top of cultivars. It is the already-aged twigs that are best suited. The bud-wood are taken from the central portions of the lignified branches. The branches chosen to make grafts are alive; there should be no signs of parasitism. They are taken from the periphery of the crown rather than inside. Check the presence of lateral or terminal buds. They must be active, but not broken.

A burst bud is a bud that has already begun to grow. A dormant bud is one that shows no activity. The ideal, for the collection of the bud-wood, is that the bud is very slightly inflated (which proves that it is not dormant), but not open (which makes a risky handling). To activate dormant buds, the graft-shoots may be stripped off 9 days prior to the collection of bud-wood or grafts in jujube cultivars.

Ideally, for the collection of the bud-wood is that the bud is slightly inflated but not open/burst

## Grafting

### Different types of grafting

Three methods have proven to be better for jujube grafting. These are:

- budding in T under-bark,
- single slot grafting, and
- approach grafting .

### T-budding under-bark or shield budding

This method of grafting is probably the most used with the jujube tree in the Sahel. The budding is simple, quick to perform and excellent recovery (up to more than 85%). It allows grafting young subjects without mutilating them and requires only a small amount of grafts since each of them includes only one eye. It has been used extensively when it comes to converting old wild jujube blossoms into improved cultivars. It is usually done on small plants with a diameter of 6 to 25 mm, in nursery or fields, during periods of active growth so that the bark is easily removed from the wood.



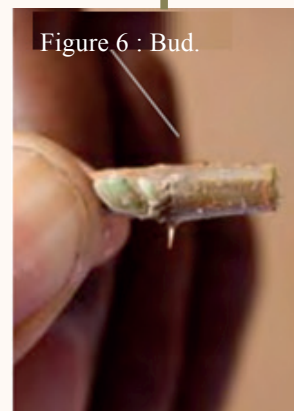
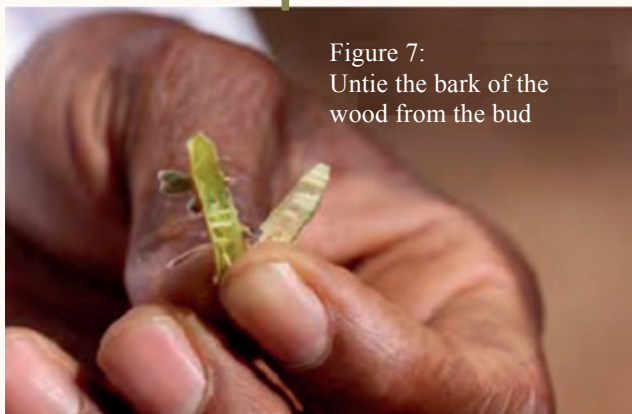
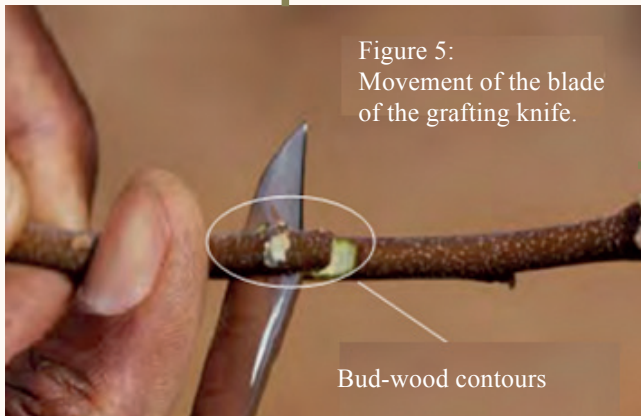
## **Period**

The budding is performed on good subjects, in two main periods:

- from April to June, with a growing bud, the bud-wood/graft develops immediately;
- from July to September, with a dormant bud, the bud-wood is united but does not give a shoot until the following vegetative re-growth.
- This second period is more commonly chosen than the first; we wait for the decline of the sap avoiding:
- grafting too early, which would expose the graft to grow prematurely before the cold season and to suffer the bad conditions of the fresh and dry winds (from November to February)
- grafting too late, when the bark does not peel off easily or hard to peel and the sap is not abundant enough to ensure an easy graft taking. August is the favorable period for the grafting of jujube trees with dormant buds.

## **Subjects and grafts**

Only young jujube trees from one to three years old, whose bark is thin and the diameter in relation to the width of the graft, are not affected. This one is always taken on a shoot of the year during vegetation and sufficiently mature; if necessary, the pruning is caused by a topping, stripping or pinching carried out eight to ten days in advance. The different stages of the budding, from the preparation of the graft branch to the lifting of the bud-wood are illustrated by Figures 4 to 7.



## **Procedure**

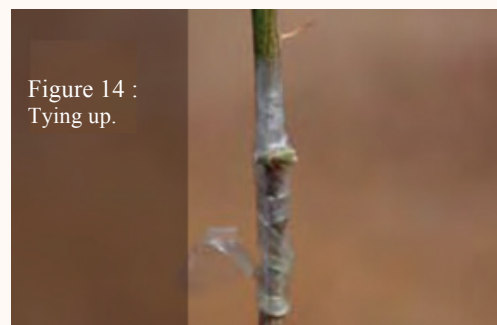
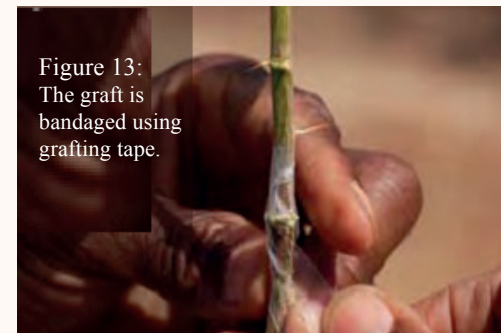
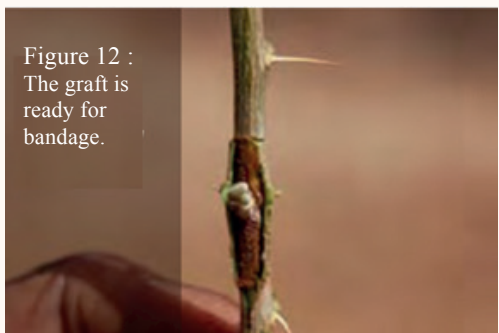
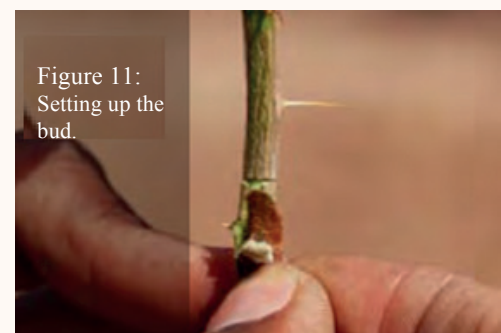
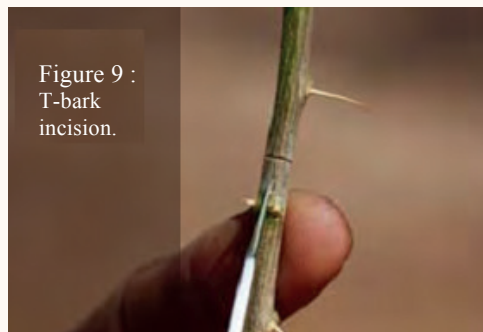
A bud is removed by removing a bark flap 20-30 mm long with a bud in the middle from the graft-branch. To have a clean cut, you must have not only a sharp grafting knife, but also use your entire blade, from the heel to the tip, by a saw movement.

On a straight and smooth part of the subject, a T-cut is made on only the bark that is lifted. Then, using the spatula of the grafting knife, we then introduced the patch that is tied up carefully, especially at the bud. The steps of the preparation of the rootstock to the establishment of the bud-wood and the tying up are illustrated by Figures 8 to 14.

The heading of the rootstock, immediately above the grafted material, takes place in February-March, a short time before the vegetation resumes. Moreover, as soon as the graft is well taken and developed; the rootstock is resized or reduced.

### **Advantages of budding**

- Overcoming incompatibility between rootstock and graft.
- Simple technique, quick to execute and excellent recovery.
- Grafting of young subjects without mutilating them and requires only a small amount of grafts since each one of them includes only one bud.



## **Cleft or top/wedge grafting**

### **Period**

The best time is in the growing period when sap is abundant (between March and October). Cleft grafting should be avoided at the beginning of September because there is excessive flow of sap from cuts on the rootstock. To prevent the graft from drowning, it is best to prune the subject a few days before, slightly above the expected grafting point. Thus, we can make the tears of sap come out before the grafting a few centimeters down. The best time is at the end of the cold season, in March.

### **Rootstocks and grafts**

The rootstock must have a diameter greater than or equal to the diameter of the graft, slightly knotty and vigorous enough; while the graft branch should be ripened/lignified, having 2 to 3 wood buds (Figure 1).

### **Procedure**

The graft, about 3 knots long, is cut at its base in double bevel (two sloping cuts in a V-shape) (Figure 19), starting the bevels at the level of the lower bud, either normally or through shouldering and so that it has one side thicker (the one with the lower bud and will be placed towards the outside of the rootstock) than the other (placed towards the inside of the rootstock).

The graft is then slid into the slot at one of its ends, matching the cambia areas of the graft and the rootstock (all jujube trees). It is advisable to slightly tilt the graft relative to the rootstock to ensure at least one-point match; however, it seems preferable to make the cambia zones coincide for as long as possible by arranging the graft in a good position and parallel to the axis of the rootstock.

It is necessary to cover the graft in a tight way with a protective aluminum foil which gives a lower temperature for the grafted area, in addition to the transparent plastic and / or only in clear polythene strip for at least two weeks and to cover carefully with the grafting plaster or tie with a plastic cut into strips all parts of exposed tissues. When the thorn of the graft pierces the plastic bandage, it does not detract from the chances of success of this grafting process. Note that the plastic cover protects the graft from drying out, and water and dust penetration to wounds.

The different steps of single and double cleft grafting, from the preparation of the graft and the branch to the insertion of the graft onto the rootstock, are illustrated in Figures 15 à 27.



Figure 15 :  
Rootstock.



Figure 16:  
Top the seedling rootstock  
where it is pencil-like, 20-30  
cm from the ground.

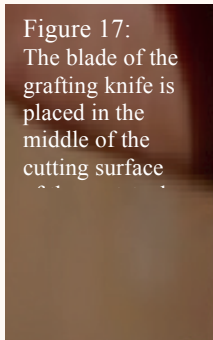


Figure 17:  
The blade of the  
grafting knife is  
placed in the  
middle of the  
cutting surface



Figure 18:  
Selecting a graft  
of the same size.  
The graft is  
about 15 cm  
long or 3 knots.



Figure 19:  
The graft is cut  
at its base in  
double bevel  
with the edge of  
the graft.



Figure 20:  
The graft  
cut in V.



Figure 21 :  
The graft is then  
inserted into the  
slot. This is the  
presentation of  
the graft (upper  
part) with respect  
to the rootstock  
(lower part) in the  
figure.



Figure 22 :  
Tying up.





Figure 23:  
Selecting a  
rootstock up  
to 10 cm in  
diameter, the  
bark is easy to  
break away

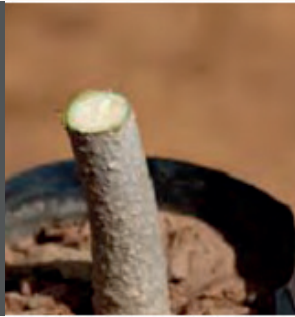


Figure 24:  
Using a knife  
make two  
parallel cuts  
about 2.5 cm  
long



Figure 25 :  
Laying out of  
grafts versus  
rootstock in  
double-graft  
grafting.



Figure 26 :  
Tying up  
grafts firmly  
with graft tape  
or  
polyethylene  
strips.



Figure 27 :  
Tying up..



## Cleft or top/wedge grafting

### Period

### Advantages from single slot grafting

- Grafting done throughout the year, except during the vegetative resting period of plants (December-February) where the graft must wait for the vegetative awakening to start. However, the graft must be fully protected from the cold and the wind weather.
- Easy and accessible technique because it is similar to the grafting of mango and citrus already popular in most rural areas.

## Approach grafting

### Period

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

### Procedure

Unlike other techniques, approach grafting does not involve the collection of scions. It only requires moving the young rootstock from the nursery to the mother-tree that is to be multiplied. On the rootstock and on the graft, superficial wounds of 3 to 4 cm in length penetrate to the sapwood which 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 tie up thereafter.

The different steps of approach grafting are illustrated in Figures 28-33. Seedlings may have to be grown in pots in order to bring them close to the mother-tree, to the ground or on the scaffoldings at the right time.

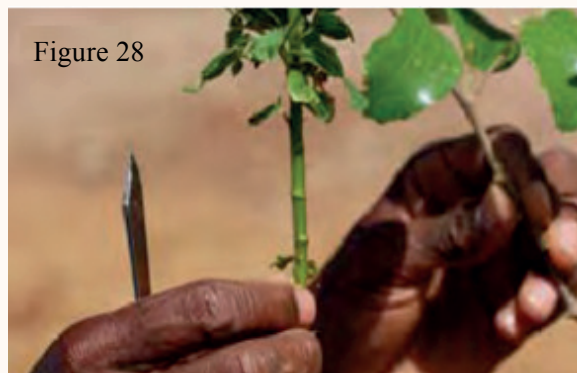


Figure 28-29: Select two same size seedlings seedlings.

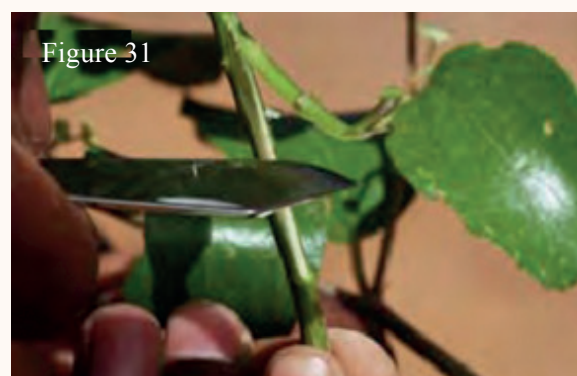
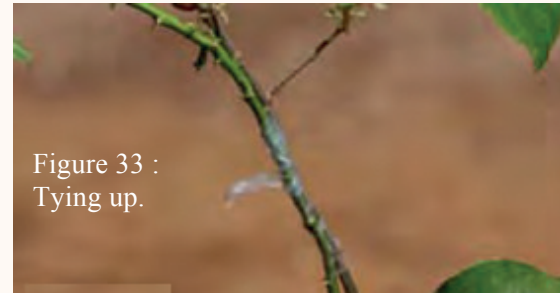
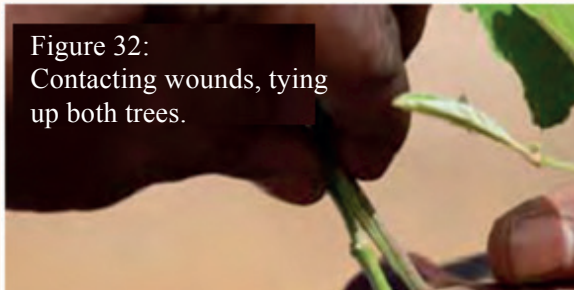




Figure 30-31: Bark incision on both sides to put in contact.



#### Advantages of approach grafting

- Very simple and easy to perform.
- Helps to circumvent the phenomena of incompatibility between graft and rootstock.
- Also offers chances of success when other grafting techniques prove difficult in practice.

The great constraint of this technique is that plants are very bulky; the bonding period is too long, and the weaning is done in a progressive way.

#### Tools for grafting jujube tree

Appropriate tools is an essential factor in the success of grafting operations. The essential equipment for grafting is given below (Figure 34).

These are the following equipment and tools:

- grafting or embossing knife (graft or shield) of good quality and sharp. The shields have a curved blade and a beak that allows lifting the bark tongue for the T-graft;
- fine-textured sharpening stone for sharpening grafters and shields;

- 90 ° alcohol to disinfect tools;
- pruning shears, sprays and plastic bags to collect grafts;
- coolers and ice packs to keep grafts cool for a few days/hours;



Figure 34 : Tools for grafting jujube tree.

- types of dressings for grafting or budding (polyethylene strips, raffia, rubber bands, adhesive tapes, biodegradable tapes) approximately 1 cm wide.
- grafting wax or white latex paint to cover the graft and prevent tissue desiccation after grafting;
- small transparent bags or polyethylene strips to cover the upper part of grafts and fine string;
- strong rootstocks and young and strong grafts in very good health;
- ID tags;

- medicine box and dressings for wounds with grafting;
- drinking water for the workers;
- writing case with indelible ink.

The appearance of wastes or regrowths or greedy below the graft / rootstock attachment zone makes the recovery uncertain of the graft. We must remove them at each appearance with pruning shears, which promotes the resumption of grafts.

A graft should be protected from clumsy movement of the graft before recovery. It will then be necessary to ensure a sustained maintenance of the future grafts by ensuring a regular and sufficient watering as well as a regular weeding. The appearance of wastes or regrowths below the graft / rootstock attachment zone makes the recovery uncertain of the graft. We must remove them at each appearance with pruning shears, which promotes the resumption of grafts. The labeling and graft identification are very important steps for the collection, in order not to make an error of confusion between different accessions from the same different source in a nursery, in a future

## Setting up of fruit orchards

### Ecological and cultural requirements

Jujube tree grows on sandy soils, stony soils, cultivated land, banks of streams and ponds. It tolerates temporarily flooded soils. It occurs in the isolated state, sometimes in pure stands. However, for more production, it is advisable to grow jujube tree on soft soil/loamy and preferably with irrigation possibilities.

A good organic content in the surface horizons is favorable for a better growth and a good productivity of the tree.

..... for more production, it is advisable to grow jujube tree on loamy soil and preferably with the irrigation possibilities.

## **Planting itself**

### **Holes digging**

One month before planting the jujube orchard, the farmer prepares planting holes.

A large hole is always preferable (example: 40 cm × 40 cm × 40 cm). The holes are filled, one month before planting, with potting soil and well-decomposed manure at the rate of 1.5 kg per hole and 0.2 kg of phosphate rock (example: Tilemsi natural phosphate in Mali), added at a dose of termiticide to limit termite damage. 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 varieties. The optimum spacing is 5 m × 5 m, or 400 trees per hectare. However, it is advisable to plant with large spacings, 10 m × 10 m or 200 trees per hectare (Figure 35), for large varieties with large crowns such as Gola (ex-India).

## **Plant maintenance**

### **Watering young trees**

Water supply from the first year promotes the recovery of young plants. Even if it is not practiced very frequently during the dry season, watering will be done very heavily at least three times a week.





Figure 35: Jujube orchard, plan of arrangement of the trees according to a spacing varying from 5 m to 10 m.

## **Irrigating mature trees**

Recovery once assured, jujube tree irrigation will be mandatory or optional depending on the goals, the site and the mode of growing (intensive or extensive fruit production). Normally, the large size of fruit trees has a big impact on the amount of water to use. The water supply can be made from a permanent watercourse or by digging a hole in the plot itself or nearby to facilitate watering.

The amount of water to be used per tree as well as the frequency of watering depends on the physical properties of the soil, climatic conditions and the stage of development of the plant. However, water supply should not inhibit fruiting because too much watering can promote vegetative development of fruit production. Normally, irrigation should be interrupted (at least one month) during the flowering period so that the water stress caused will cause better flowering. The base of the trunk is protected from the water by a double bowl to prevent the immersion of the base of jujube trees does not favor the appearance of cryptogamic 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 amendments will be applied. The fertilizers generally brought are: phosphorus, potash or ashes and calcium.

Using an organic or chemical fertilizer makes it possible to put it at the disposal of the plant the nutrients it needs. In the Sahelian zone, farmers are advised to use the organic manure that is easier to obtain. In general, jujube trees need 500 to 1000g of nitrogen, 400 to 800g of Phosphorus and 100 to 200g of Potassium according to the age of the tree, the soil and the climatic conditions.

In the Sahelian zone, farmers are advised to use organic manure that is easier to obtain.

## **Initial pruning**

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

It is easy to harvest jujube fruit when the trees are small. For this, it is desirable to cut them to a height of 1.2 to 1.5 m. The main stem is cut between 0.8 and 1.2 m above the first 2 to 5 secondary branches. The side branches will take over and form frames to support the fruits. It is the twigs of the year that bear fruit; it is not wise then, when approaching the Sahelian winter (May, June), to clear all the trees of the jujube orchards, while thinking of sprinkling the impact of pruning with a mixed antiperspirant to a fungicide (example: benlate).

#### Protecting against animals

Domestic and wild animals can cause serious damage to young trees and well-established trees. Building a fence (preferably a hedge) around the plantation can help address this problem.

### **Orchard maintenance: pruning, weeding, crop combination**

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

During the first years after the establishment of the jujube trees, one can take advantage of the large spacing between the trees to make a cash crop until the main crop - the jujube tree - occupies all the available space. Plants such as legumes, vegetables, cover crops, etc., are potential crops to be associated to the jujube tree.

### **Protection against diseases and pests**

At the time of flowering, insects visit flowers of the jujube tree. These visitors include not only pollinating insects but also pests for jujube fruit. These insects are among others: *Ammophila sp.*, *Apis mellifera* (honey-bee), *Cyphonomyx croceicornus*, *Dasyphora cyanella*, *Lonchura sp.*, *Lycus semiaplexus*, *Milabris nubica*, *Musca domestica*, *Musca sp.*, *Syntarucus sp.* and a large diversity of ants.

The non-exhaustive list of jujube tree insect visitors is given in Tables 1 and 2, respectively for Burkina Faso and Mali.

Table 1: List of insects attacking jujube tree in a fruit orchard in Ouagadougou, Burkina Faso (according to Ouédraogo et al. 2006).

Table 1: List of insects attacking jujube tree in a fruit orchard in Ouagadougou, Burkina Faso  
(according to Ouédraogo et al. 2006).

Genera and Species	Family	Nature	Parties attacked
<i>Acrida sulphuripennis</i>	Acrididae	Orthoptera	Leaves
<i>Agonoscellis haraldi</i>	Pentamidae	Heteroptera	Sap and leaves
<i>Brevicoryne</i> sp.	Aphidae	Homoptera	Sap
<i>Chromoderes</i> sp.	Curulionidae	Coleoptera	Leaves
<i>Hullula</i> sp.	Pyrilidae	Lepidoptera	Leaves
<i>Pachycondyla senaarensis</i>	Formicidae	Hymenoptera	Fruits
<i>Plutella</i> sp.	Hyponomentidae	Lepidoptera	Leaves
<i>Tenebrio guineensis</i>	Tenebrionidae	Coleoptera	Leaves

Table 2: Non-exhaustive list of visiting insects of jujube in a mother-block at the ICRAF WCA / Sahel  
Research Station (according to Asockba R., 2002).

Genera and Species	Nature	Family	Name in bambara	Name in English
<i>Ammophila</i> sp.	Hymenoptera	Sphecidae	Dodo Li	Wasp
<i>Apis mellifera</i>	Hymenoptera	Apidae	Didé	Bee
<i>Dasyphora cyanella</i>	Diptera	Muscidae	Limogobleni	Red fly
<i>Lonchra</i> sp.	Diptera	Calliphoridae	Limogoba	Blue fly
<i>Mantis religiosa</i>	Orthoptera	Mantidae	Allah mouroudian	Man-eater
<i>Musca domestica</i>	Diptera	Sepsidae	Limogodjema	Whitefly
<i>Syntarucus</i> sp.	Lepidoptera	Lycaemidae	Frifri ni	Butterfly



Some of them lay eggs like the fruit fly (*Ceratitis capitata*, *Carpomya vesuviana*) so that at the time of fruit ripening, larvae are often observed. These attack the fruit pulp causing great damage. A fight is therefore necessary against these attacks at the time of the flowering of all the accessions. In this regard, using biological insecticides is recommended based on neem seeds, Carapa procera seed oil or Lannea microcarpa. However, a farmer in Ségou (Mali), Mrs. Mariko Mariam Keïta, successfully uses an insecticide in her jujube orchard of more than 2 ha (see box) to combat against fruit fly attacks.

Mrs. Mariko, successfully uses a liquid insecticide in her jujube farm of more than 2 ha, in this case: at a rate of 125 cc / 100 liters of water, during the whole flowering period, from June to October. The treatment is stopped one month before the fruit ripens.

There was also the presence of defoliating pests. The high humidity and the direct contact of the water with the collar of the cultivars cause gummosis and other cryptogamic diseases. It has often been found that growths in the form of pimples gain in volume over time; the surface of the buds is rough and purple in color on the main stem. Trees leaves are also often attacked. The attack causes a grouped stunting of leaves characterized by their extreme smallness. Some farmers have described the attack as a leprosy of the improved jujube trees. By the way, it looks like a peanuts' rosette.

Birds and bats also feed on jujube fruits as they ripen. This ripeness manifests as a high concentration of fruit juice, a remarkable size and a color of the fruits passing from green to yellow with a strong odor attracting birds and bats.

As a means of control, it is recommended to cover the entire tree with a large medium horticultural net.

# Overall conclusion

Grafting is often criticized for reducing the longevity of tree species, and the united points also develop protuberances which make grafting very frightful; then, by locating the grafting region lower, this appearance will be treated. Research on compatibility between rootstock and graft significantly improves the longevity of grafts.

At what time of year is appropriate for grafting a jujube cultivar? How to get a graft? Each of these questions is answered in this richly illustrated technical manual. It delivers simple and easy methods that will guide step by step each of your handlings.

Each stage is carefully described and supported by drawings, very explanatory photographs, which received a favorable echo among the Sahelian arboriculturists during the different fora. You will also find periods that are conducive to handling these jujube cultivars. Grafting is an operation that requires thoroughness and patience. But your efforts will soon be rewarded by a high production of quality fruit.

Jujube tree or Sahelian apple cultivars possess exceptional qualities: their fruits are sweet, large and abundant; they are resistant to certain parasites, early and easy to the pruning practice. However, their reproduction by seed does not guarantee that these exceptional qualities are found in plants derived from seeds. It is therefore necessary to find a mode of vegetative reproduction. Reproduction by cuttings gave poor results, while grafting is very easily controlled by Sahelian farmers. Jujube tree cultivars were grafted on all jujube species adapted to the Sahel, and even more, which gave them a better future in the Guinean forest zone, in the pre-Guinean zone, in the southern Sudan zone, north, in the southern Saharan and northern zone.

Rootstocks from sowing seeds of cultivars have a prodigious growth. In addition to being able to provide a good growth to the grafts that grow on them, they strengthen the compatibility between grafts and rootstocks.

In terms of the vigour of the rootstock species, they come after *Ziziphus mucronata*. Establishing a jujube cultivars' orchard requires a thorough knowledge of the vigor of the rootstocks,

the form of their rooting, the adaptability to the soil, the resistance to diseases and pests.

Grafting jujube cultivars takes place within four stages: rootstock preparation, graft preparation, using the graft on the rootstock, removing the graft when it is a side grafting. Removing the graft consists in progressively cutting the rootstock above the grafting zone with a view to its disposal when graft recovery is ensured.

Using these simple techniques could ensure a more productive and healthy jujube orchard for the Sahelian farmer.

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