

Citrus nurseries and planting techniques

B. Aubert, G. Vullin



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and planting techniques

Abstract

Citrus nurseries and planting techniques is a practical guide for nurserymen who propagate fruit plants or ornamental citrus and supply the market with certified elite/quality planting material. In addition to registered nurserymen, this manual is also intended for small-scale family nurseries in the tropics and subtropics, and amateurs fascinated by the beauty and symbolism of *Citrus*.

This fully illustrated manual provides a detailed description of procedures for obtaining the optimum growth of rootstocks, prior to and after budding, and for transplanting the young grafted plants into the field. Each technical step is described in separate chapters with relevant illustrations of the recommended techniques. Both conventional outdoor propagation methods and more elaborate container-grown indoor methods are described. Specific aspects such as micrografting and microcutting are discussed together with general nursery practices ranging from the disinfection of pruning tools and of nursery surroundings to the mycorrhization, and the evaluation of the porosity or salinity of the growing media, etc.; concise tables assist any decision-making, e.g., in the choice of rootstocks, the assessment of pest and disease risks when budding, and, more generally, on the layout of nursery premises or citrus plantations.

Black and white, and colour plates illustrate common mineral deficiency symptoms as well as diseases of economic incidence.

This practical guide for citrus nurseries and planting techniques also includes, at the end of each chapter, an extensive and updated bibliography.

Techniques

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GTZ

CIRAD

The Authors

Bernard Aubert has successfully been conducting various citrus and fruit trees programmes for nearly three decades in North Africa, Latin America, Africa, Indian Ocean, and Asia before managing the "Citrus and perennial fruit crops" programme at Cirad-f1hor.

Guy Vullin, agronomist for Cirad-f1hor, used to be director of the Agricultural Research Station of San Giuliano in Corsica specialized in citrus crops in mediterranean regions.

The help of eN. Roistacher, emeritus plant pathologist at University of California, Riverside, USA, and Dr Hinz K. Wutscher of the Horticultural Research Laboratory, Orlando, Florida, USA, is gratefully acknowledge for the detailed editing of the chapters and useful suggestions.

List of contributors

R. Carmine, Luxembourg garden, Paris, France
R. Cottin, Cirad-flhor, Director of SRA-San Guiliano, Corsica
F. Dosba, Inra-Ensam, chair of Fruit Arboriculture
J. Godefroy, Cirad-f1hor, pedologist
M. Labergère, CTIFL, Lanxade
E Laville, Cirad-flhor, pathologist
J. Marchal, Cirad-f1hor, physiologist
B. Moreau, Cirad-flhor, agronomist
P. Ollitrault, Cirad-flhor, geneticist
A. Sizaret, Cirad-f1hor, agronomist

The authors would like to thank the following people for their help in collecting technical data:

A. Azzib, director of GIAF, Tunis, Tunisia
J.F. Breton, *orangerie* of Luxembourg garden - France
D. Ezzoubir, Agricultural Property, Rabat, Morocco
G. Galletti, Conservator, *orangerie* of Castello garden, Florence, Italy
F. Heulin, *orangerie* of Luxembourg garden - France
A. Lee, Outspan Foundation Block, Port Elizabeth, South Africa
M. Nahmi, Agricultural Development Company, Rabat, Morocco
L. Pautrat, *orangerie* of Versailles Palace, France
A. H. Welch, Viveiros do Forai, San B. De Messines, Algarve, Portugal

This book was edited by CIRAD, with the financial support of the GTZ, and published in French for the 5th International Congress of the ISCN (March 1997 - Montpellier France). This English translation is also an updated version of the first edition.

CIRAD (Centre of International Cooperation in Agronomical Research for Development) is a scientific organization specializing in tropical and subtropical agriculture. It was developed in 1984 by merging different agronomic research and development organizations working on tropical and subtropical plant commodities as well as on forestry, veterinary, and food sciences.

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Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
Dag-Hammarskjöld-Weg 1-D-65760 Eschborn (Germany)
Telephone (0-6196) 79-0- Telefax (0-6196) 79-1115

The ISCN (International Society for Citrus Nurserymen) is a non-profit organization which was founded in April 1981. Its objective is to promote high quality procedures for propagating citrus plants. It operates on a budget from members' contributions. Under the slogan "Quality trees for quality fruits", ISCN has four main objectives:

- To strengthen contacts between nurserymen and researchers who specialize in genetic sciences, pathology, and physiology. This is being pursued with the international congresses that ISCN organizes once every four years.
- To advise and inform nurserymen through information bulletins, publications, and pamphlets.
- To promote all the activities which aim at preventing the dissemination of diseases transmitted through grafting, and, more generally, the spread of harmful organisms which would have dangerous economic effects.
- To lead working groups charged with evaluating the performance of new selected rootstocks and varieties.

Contact:

Chairman of ISCN, Cirad-flhor, PO Box 5035, 34032 Montpellier Cedex 1, France.
Membership Secretary, Tolleys Nurseries, POB 2, Renmark, Australia 5341.

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Preface

This book is intended mainly for plant propagators whose activities of supplying and diffusing planting material are far beyond the simple task of plant delivery. As professional nurserymen, they are able to serve a real social function of promoting and amplifying elite citrus planting material. Such an objective requires: i) updated cultural practices in nursery management, ii) careful clonal propagation procedures throughout the propagation chain for an improved selection.

In this respect Cirad-flhor has a rich experience: first of all, as the manager of a large germplasm collection of clean nuclear stock, with its partner Inra at SRA Corsica, second, as an R and D institution in direct contact with the main operators involved in research or production, and, third, as the manager of registered nurseries producing certified citrus trees in overseas French territories (West Indies, Indian Ocean, Pacific), or within specific technical cooperation programmes in Africa (countries in the south of Sahara), Middle East, Latin America, South East Asia.

The time has come to gather the important “*know-how*” accumulated for half a century in a wide range of ecological situations, into this comprehensive and easily accessible manual. This task has been addressed in *Citrus nurseries and planting techniques*. In this highly referenced guide, Bernard Aubert, and Guy Vullin, citrus scientists and experts for the mediterranean and tropical regions, answer the long awaited expectations of nursery professionals. The book combines updated and solid scientific background with a rich experience accumulated for half a century by Cirad-flhor and SRA San Giuliano. Although especially dedicated to modern professional citrus nurserymen, this guide is also of interest to small nurseries run by countless families and villages in the tropics.

After presenting the historical origins of citrus nurseries in Europe and various parts of the world, the authors describe in a straightforward and practical approach the various steps of the scion formation, and the transfer of the young grafted tree into the orchard. The results of field observations and experiments carried out in different producing regions are also included.

This well documented and illustrated reference book will be a useful manual for practitioner nurserymen.

Jean-Pierre GAILLARD
Director Cirad-flhor

Introduction

Citrus plants native to tropical and sub-tropical Asia have been disseminated throughout the world for about four millennia. Their introduction in the mediterranean basin is very old and traces back to the East-West exchanges during the silk trade. However, it was not until after the 1500's A.D. that citrus plants were disseminated worldwide by navigators and redistributed from Europe to tropical Africa, America, and Australia. The *Citrus*, *Fortunella* and *Poncirus* diversification, as well as their geographical dispersion, were largely influenced by men who originally took advantage of the propagation by seed. On one hand, this method offered the possibility of a true-to-type multiplication for polyembryonic cultivars, e.g., acid lime, and most of mandarins and oranges, and on the other hand, the possibility of segregating interesting genetic traits in the case of monoembryonic varieties, e.g., pomelos and citrons.

The development of nursery techniques was originally aimed at overcoming the problems of environmental constraints. The idea of cultivating composite individuals originating from the association of a rootstock and a scion had the advantage of maintaining the true-to-type commercial cultivars, and solving to some extent the adverse effect of soil factors such as water-logging, compaction, salinity, alkalinity, *Phytophthora* sp. epidemics of 1840 onwards, followed several decades later by tristeza spread, and nematodes. The behaviour of the grafted plants made it possible to produce desirable types of fruit trees with good canopy characteristics, and a stronger and more vigorous root system than non-grafted plants.

The first part of this book presents the techniques for assembling and rearing grafted trees (i.e., the production of rootstocks, the production of budwood, and the assembly of the scion/rootstock combination). In following the recommendations mentioned in this book, nurserymen are in a better position to answer farmers' questions concerning various production constraints.

The second part deals with the transplantation of nursery plants into the orchard, and the appropriate care needed to handle the young trees up to the bearing stage.

Mastering these different steps requires a practical knowledge in combining genetics, entomology, physiology, and soil science. The main objective of this manual is to present a detailed description of these technical procedures, and to explain the sequence of events leading to the formation of the young grafted plant and its transfer to the field.

This manual is intended as a practical guide for nurserymen and citrus growers. The recommendations mentioned are the result of numerous field observations accumulated for over 40 years by Cirad-Ifhor and Inra in North Africa — first Morocco, then Algeria and Tunisia — and in various tropical countries (West Indies, Latin America, Africa, Indian Ocean, and the Asia-Pacific region). Lessons learned from countless nursery and field experiments are also taken into account.

Recent developments in physiology and biotechnology are also presented to inform the nurserymen of new possibilities in the art of propagating elite citrus plants for both fruit production and ornamental purposes.

A brief historical overview on citrus nurseries

Citrus plants have been cultivated and enjoyed for over 4,000 years, and early horticulturists were keen to propagate a highly valued planting material requested for pleasure gardens and/or orchard plantations. The first writings dealing with citrus propagation techniques go back up to more than a millennium. Since then constant improvements of propagation methods have been developed by generations of botanists and horticulturists and are now being approached with ever increasing scientific rigor.

▲ Origins of propagation techniques for citrus

▲▲ In the Eastern and Western Mediterranean

According to EL FAIZ (1995), one of the oldest writing dedicated to citrus propagation is *"The book of Nabatean agriculture"* published in Damascus (Syria) by QUTAMIA between the 3rd and 4th century A.D. This manuscript described ancient techniques of plant propagation (including citrus trees) bequeathed by the Mesopotamian civilization.

In the 8th century A.D., ABD-AL-RAHMAN, the first Caliph Ommeyad of Cordoba (Andalusia, Spain), decided to lay out a citrus garden attached to the great mosque he had ordered to build. For this purpose, he sent emissaries to Syria asking them to bring back the precious planting material then available (such as sour oranges, citrons, lemons), as well as a copy of the QUTAMIA's manuscript. By 904 this document was translated from old Syrian into Arabic, and soon inspired successive medieval-Andalusian agronomists such as IBN AL AWWAN, IBN BASSAL, IBN HAJJAZ, and even ABU ZACARIA. The concept of a citrus nursery was clearly identified for the first time by IBN HAJJAZ in 1074 as *"the*

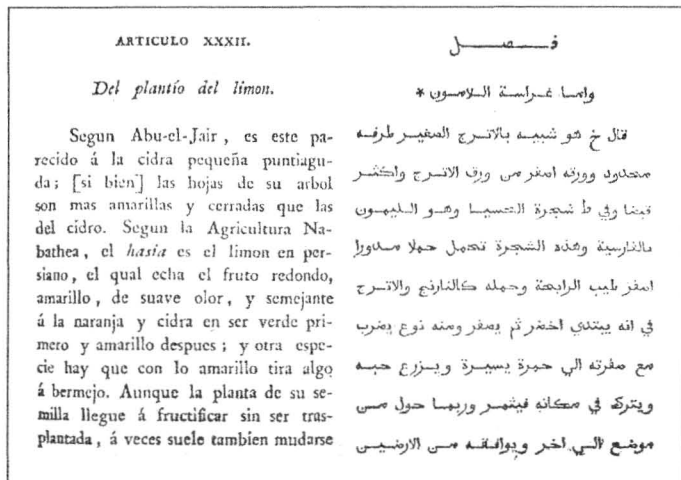
place where initial plantings are established in such a way that they can be subsequently transferred to final plantation sites”.

The far more detailed works of IBN BASSAL described various methods of citrus propagation such as seedlings either in pots or in seedbeds, cutting procedures for citrons and lemons, and various transplanting techniques. They also mentioned different methods of grafting, budding, and interesting advice for preparing rootstocks or maintaining budwood for long distance transportation in “terra cotta containers with a very narrow neck that had never contained any kind of oil but only water, up to the time of their use”.

The above nursery skills, combined with the tremendous efforts devoted to collect and supply water to the planted areas, had materialized in the layout of prestigious citrus “gardens” such as the Agdal in Marrakech (Morocco) with up to 60,000 trees, or that of Buhayra (Sevilla, Spain). These plantings were probably the largest citrus orchards ever established at that time. Their creation followed the early pleasure gardens requested by the Caliphs to enhance urban or religious architecture. This was precisely the case of the Cordoba mosque, whose adjacent citrus garden’s layout was the exact image of the pillars of the famous building. The transition from symbolic or religious plantings to real production units was then accomplished within only a few decades.

It is clear that, without an excellent mastery of nursery practices, the medieval-Andalusian agronomists of Western Mediterranean would never have implemented such ambitious plantation/planting tasks, considering the small amount of initial vegetative material received from Syria (EL FAIZ, 1996). Their technical and scientific writings re-edited and translated several times can still be found in the old libraries of Andalusia, Rabat, Madrid, and Paris (figure 1).

Figure 1. An extract of the manuscript of ABU ZACARIA (12th century A.D.) on the citrus nursery; re-edited in Spanish and Arabic (quoted by SANTAMARIA and PALOMO, 1996).



▲▲ In Asia

Towards the same period, at the other end of the globe, HAN YEN CHE, a Chinese agronomist from Zhejiang, was writing his "Treatise on oranges" (1179). Despite the fact that a great part of his writings are dedicated to the pomological descriptions of about 20 cultivars, it also contains valuable data on propagation of citrus by seedlings, cuttings or grafts, and on the necessary care to be taken: watering, soil fertility, and control of various pests (figure 2).

▲▲ In Europe

As the medieval-Andalusian citrus practices were gradually reaching the European courts (especially the Italian ones), they had to be reformulated to meet the specific use newly conferred to citrus plants. The MEDICI family in Firenze (Tuscany), promoter of a renewal in garden architecture, established a rich collection of citrus at the Castello palace. In 1558, the French historian BELON mentioned the lavishness of this collection built up through the contacts with the Arab horticulturists.

The MEDICI method for growing citrus consisted in planting them in large *terra cotta* pots that were then transferred during the winter into *stanzone per vasi*. These premises were soon to become the "orangeries". This live collection museum still exists and GALETTI, its present curator, recently published an official inventory (1996).

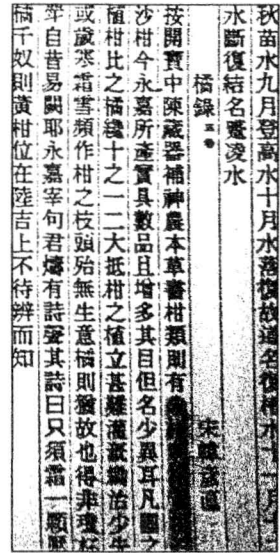


Figure 2. Extract from HAN YEN CHE's work written in 1179 (public library of Fuzhou Fujian, China).



Figure 3. The Castello palace (Italy) old citrus collection in terra cotta containers.

Through royal alliances, the Florentine traditions for citrus reached the French court in the 16th century with two MEDICI princesses married to the Royal House of France. The prestige ascribed to the fruits of the Hesperides garden was such that it led the great architects of the 17th century to conceive *orangeries* as prestigious greenhouses to enhance the royal architecture, e.g., the *orangeries* of Luxembourg Palace in Paris, or that of Sceaux, and Versailles. The latter was highly prized by Louis XIV not only for the acclimatization of rare plants but also as a lovely entertainment place for banquets and plays (figures 4 and 5).



Figure 4. Citrus trees of Versailles Palace (France) cultivated in large oak containers with hatch walls specially designed to transplant easily the developing trees. In old times, horse drawn carriages were used to transport the trees.

To complete the illustrious architectural work of MANSART who had brilliantly designed various royal *orangeries*, DE LA QUINTINYE (1730), the chief gardener of Louis XIV, devised on his own a specific rooting media most favorable to orange growing.

The rooting substrate for citrus recommended by DE LA QUINTINYE

Half mixture of the following sieved ingredients: cow dung, powdered night soil, pigeon droppings, grape marc, sheep manure, and composted sod.

Half mixture of coarse Fontainebleau sand.

Concurrently, he developed specific oak containers with hatch walls to transfer the developing trees into larger boxes where they would be maintained for several decades. This clever technique is still perpetuated today in French gardens, palaces, and manors. However, the subtle mixture of DE LA QUINTINYE'S rooting medium has been revised according to new formulations which took into account criteria such as porosity, electric conductivity, and water holding capacity.

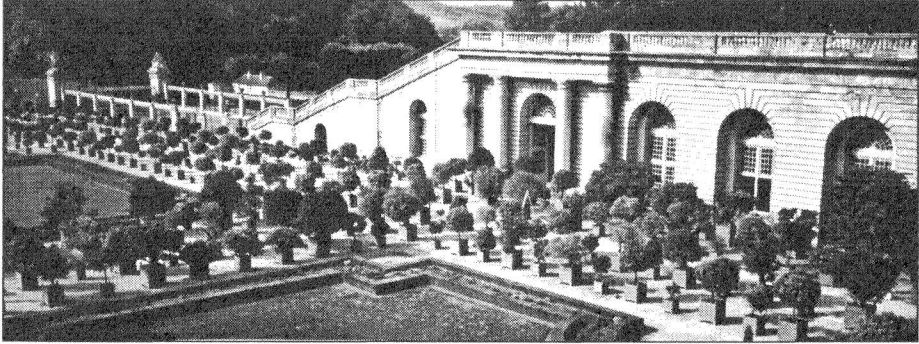


Figure 5. One aspect of the orangeries designed by Mansart for the Versailles Palace (17th century).

▲ Recent development of nursery practices

▲▲ Transition in our time

Citrus nurseries developed gradually with the constant increase in fruit production and demand for essential oils of sour oranges, sweet oranges, and bergamots.

The first center dedicated to citrus activity was built near Lecce in the Italian Pouilles. It was developed by CORRADO, a religious man of the Celestian order, who published his remarkable treatise on *“The physiology of the citrus, and how to control and multiply them”* (Naples, 1787) (figure 6).

Ten years later, in 1797, CAVANILLES stressed the importance of nursery activity and citrus plantations in Valencia, Spain.

The technology developed in these European countries proved to be crucial for the reinforcement of the citrus nursery practices in the mediterranean region and the introduction of the citrus cultivation in the New World.



Figure 6. Front page of VINCENZO CORRADO's work.

The *Phytophthora* epidemics that developed worldwide (BONAVIA, 1888) resulted in the rapid development of tolerant rootstocks such as the sour orange.

▲▲ Twentieth century

The citrus industry developed rather slowly at the beginning of the 20th century due mainly to the economic difficulties arising from the two world wars. However, in the mid forties, world citrus cultivation soared remarkably thanks to the use of sour oranges as the conventional rootstock. The choice of this rootstock among other things made it possible to better control losses inflicted by *Phytophthora* sp. attacks. Nevertheless, sudden difficulties arose in Argentina and in Brazil with the accidental introduction of tristeza, attributed to the use of contaminated budwood coming from South Africa (ZEMAN, 1931 ; BITANCOURT, 1943). In no less than 15 years these losses added up to several tens of millions of trees (COSTA, 1956).

The necessity of replacing sour oranges with other rootstocks forced the authorities of the State of São Paulo (Brazil) to launch the first major sanitation programme by nucellar selection (MOREIRA, 1961).

Then, thanks to the citrus pathologists of California and Florida, rapid changes were made in the basic knowledge of viral diseases transmitted by graft (FAWCETT, 1936). The creation of the International Organization of Citrus Virologists (IOCV) in 1957 benefited the citrus countries worldwide; in the Mediterranean Basin, for instance, virus-free conservatories were built in Morocco and France (Corsica) by the late 1950's under IOCV guidance.

The detrimental effect of graft transmissible diseases was remarkably presented and highlighted in the "*Illustrated Guide of Virus and Virus-like Citrus Diseases*" published by BOVE and VOGEL (1980).

Meanwhile, a new sanitation procedure by shoot tip grafting had been initiated in California (MURASHIGE *et al.*, 1972), and, subsequently, perfected by NAVARRO *et al.* in 1975, to be applied on a large scale in Spain, Corsica, Turkey, and in numerous citrus growing countries of the Old and New Worlds. The ability to rapidly obtain virus-free lines without the juvenility problems inherent to nucellar selections gave considerable impetus to citrus nurseries which could henceforth rely on safe planting material. This motivated a group of professionals and scientists specialized in citrus propagation to start the International Society of Citrus Nurserymen (ISCN) in March 1981. This non-profit organization is aimed at promoting safe and efficient techniques of multiplication of quality planting material. Before the turn of the century, ISCN has organized five international congresses (Valencia, Spain, 1981; Arvin, California, 1985; Remark, Australia, 1989; Johannesburg, South Africa 1993, and Montpellier, France, 1997). The next one is planned for the year 2001 in Brazil. In its congress proceedings, ISCN has already published