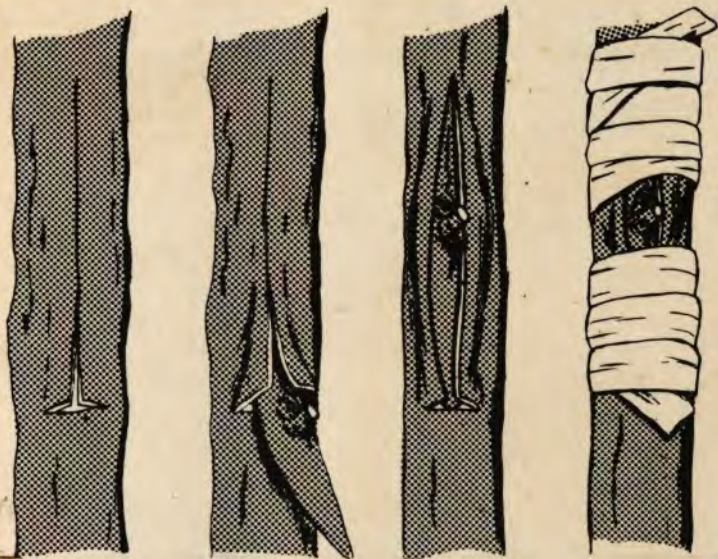


# IICA



## BB TRUS PROPAGATION MANUAL

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Fruit Crop Specialist, IICA

BRIDGETOWN, BARBADOS

1987

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The Inter-American Institute for Cooperation on Agriculture (IICA) is the specialized agency for agriculture of the Inter-American system. The Institute was founded on October 7, 1942 when the Council of Directors of the Pan American Union approved the creation of the Inter-American Institute for Agricultural Sciences.

IICA was founded as an institution for agricultural research and graduate training in tropical agriculture. In response to changing needs in the hemisphere, the Institute gradually evolved into an agency for technical cooperation and institutional strengthening in the field of agriculture. These changes were officially recognized through the ratification of a new Convention on December 8, 1980. The Institute's purposes under the new Convention are to encourage, promote and support cooperation among the 29 Member States, to bring about agricultural development and rural well-being.

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The contributions provided by the Member States and the ties IICA maintains with its twelve observer countries and numerous international organizations provide the Institute with channels to direct its human and financial resources in support of agricultural development throughout the Americas.

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In order to attain these goals, the Institute is concentrating its actions on the following five programs: Agrarian Policy Analysis and Planning; Technology Generation and Transfer; Organization and Management for Rural Development; Marketing and Agroindustry; and Animal Health and Plant Protection.

These fields of action reflect the needs and priorities established by the Member States and delimit the areas in which IICA concentrates its efforts and technical capacity. They are the focus of IICA's human and financial resource allocations and shape its relationship with other international organizations.



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**CITRUS PROPAGATION MANUAL**

by

**RAFAEL MARTE**  
Fruit Crop Specialist IICA

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## PREFACE

*Citrus Crops have become popular in all Caribbean Countries. The methods of propagation are basically the same everywhere, with slight modifications in each particular country. These adaptations sometimes help to improve the efficiency at the nursery but many times may also result in the introduction of technical difficulties.*

*Many people do not realise that most of the problems found in a citrus grove originate in the nursery e.g. fruit touching the soil in the grove, frequently results from poor nursery training; tree death, resulting from foot rot Phytophthora spp., is often the consequence of a bad choice of stock, or budding too low; many virus infections often result from the use of contaminated budwood, etc. A well organized nursery and a careful propagation process undoubtedly constitutes the first steps towards the establishment of a successful citrus grove.*

*The ideas presented in this publication are oriented to help farmers and technicians to improve efficiency in a citrus nursery and avoid the difficulties that may later be responsible for major constraints in the Orchard.*

## ACKNOWLEDGEMENTS

*The Author acknowledges the logistic support of the Ministry of Agriculture in Barbados, Guyana and the Windward Islands.*

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# THE CITRUS NURSERY AND ITS COMPONENTS

Many people do not realise that most of the problems found in a citrus grove originate in the nursery e.g. fruit touching the soil in the grove, frequently results from poor nursery training; tree death, resulting from foot rot (Phytophthora spp.) is often the consequence of a bad choice of stock, or budding too low; many virus infections often result from the use of contaminated budwood, etc. A well organized nursery and a careful propagation process undoubtedly constitutes the first steps towards the establishment of a successful citrus grove.

The main components of a citrus nursery (Fig. 1) are: The **seedbeds**, the **budding area**, the **soil treatment and potting sheds**, and **storage room**. Other aspects to be considered are, offices, sales area, soil storage, mist house, recuperation room, etc. Contrary to what is found in the majority of citrus nurseries, the budwood plot should not be located in the nursery premises, since both the potential for contamination by any given pathogen or materials, and the danger of their subsequent distribution into the field could be increased.

## The Seedbed

It is difficult to find a location which meets all the requirements for an ideal seedbed. In reality, the available sites have to be modified to meet our requirements.

In general, the seedbeds should be somewhat separated from other components of the nursery, and far away from established citrus plants. This will minimize pest infestation and/or disease infections. Visitors, especially citrus growers, should not be allowed to enter the seedbed area, since their clothes or shoes could constitute potential implements of contamination.

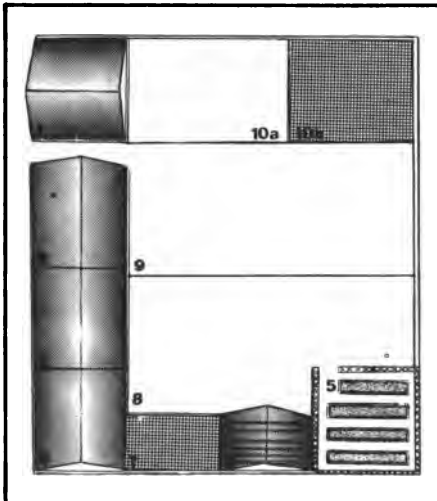


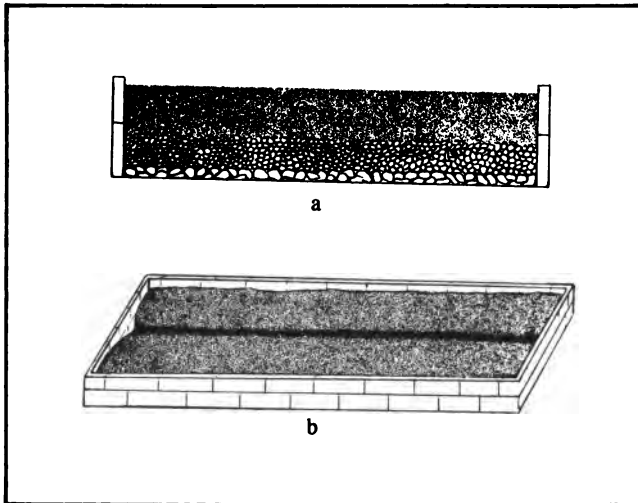
FIG. 1 MAIN COMPONENTS OF A NURSERY:

- 1) Office and Storage
- 2) Soil Storage Shed
- 3) Soil Treatment Shed
- 4) Soil Potting Shed
- 5) Seedbeds
- 6) Misthouse
- 7) Recuperation Room
- 8) Budding Area
- 9) Growing Area
- 10) Sales Area
- 10a) Open
- 10b) Shaded (Saran net)



Good internal drainage is essential for a rapid, healthy growth of citrus seedlings in the seedbed. The media should be well prepared in order to facilitate good germination of seed. Ventilation is also necessary. When however, the nursery is in an area exposed to high wind intensity, it is important to provide the necessary protection – wooden walls and saran netting are very useful for this purpose. Cemented, rectangular beds (1m wide x 10m long and 0.40m high), should be constructed parallel to each other – the base should not be cemented. The floor should be specially prepared by placing large stones and then gravel, to facilitate drainage, and to eliminate excesses of water (Fig. 2).

The seedbed is then filled with a mixture of soil and sand in varying proportions. The proportions of these materials in the mixture is according to the texture and /or structure desired. The heavier the soil available, the greater the proportion of sand used. Other materials such as peatmoss, perlite, vermiculite, saw dust, etc. are also useful. Their use depends on their availability and cost.



**FIG 2. THE CITRUS SEEDBED.** a) Cross section. Note three layers: From top to bottom, 1) Soil medium, 2) Gravel and 3) Stones. b) Side view. The non-cemented bottom is prepared in a "V" shape to facilitate drainage.

The following are examples of the proportion used:

- a) 1 (part) clay soil: 3 (parts) sand
- b) 1 (part) sandy or loamy soil: 1-2 (parts) sand
- c) 4 (parts) loamy soil: 3 (parts) peatmoss: 1 (part) sand

## DISINFECTION OF THE SOIL MEDIUM

The soil media must be disinfected to avoid contamination from fungi and bacteria, and to eliminate pests, nematodes and weed seed. The only exception to this rule, occurs when commercial materials which are already sterilized (e.g. perlite, peatmoss, vermiculite, etc.), are used for the first time. Today, various disinfection methods are known. The advantages and disadvantages of these however, must be considered in order to select the most appropriate one in each case. The disinfection methods can be divided into two groups:

- (1) those requiring the use of heat as a mean of sterilization.
- (2) those requiring the use of chemicals.

1) **The use of heat in the sterilization of the soil media:** This process employs different systems, with various adaptations, but the principle is basically the same. The media is subjected to a stream of hot air or steam for 1½ hours at 100°C. These systems control bacteria, fungi, nematodes and seed weeds. The main advantage of these systems is that the medium can be used the same day it is treated, without residual effects.

2) **The use of chemical:** The main advantage of this system is the low initial investment required. The main disadvantage lies in the longer waiting period necessary before the medium can be safely used. Among the main chemicals used (Table 1) are methylbromide, vapam (sodium N-methyldithiocarbamate dihydrate) formol 40% (formaldehyde) and Dazomet i.e. Basamid<sup>R</sup>.

**Table 1.** Dosage and waiting period recommended for different chemicals used in the sterilization of soil substrate for seedbeds and containers.

PRODUCT	Dosage	Minimum waiting period
Methylbromide	1.5lbs (680g) x 10m <sup>2</sup>	5 days
Vapam	1 lt. /50 lt H <sub>2</sub> O x 10m <sup>2</sup>	19 days
Formol 40%	1 lt. /50 lt H <sub>2</sub> O x 10m <sup>2</sup>	17 days
Dazomet	500g/ x 10m <sup>2</sup>	19 days

The growth of seedlings could be temporarily retarded in fumigated or heat-treated soil. This retardation has been attributed to the inhibition of phosphorus absorption, and the reduction in the absorption of copper and zinc by the plant. The lengthening of the waiting period before planting, the application of high dosages of phosphorus in the initial stages of growth and inclusion of nutritional sprays of copper and zinc for plants growing in this medium is therefore recommended.

## GROWING THE ROOTSTOCK

### Selection of the Seeds

Several citrus and other non-citrus species have long been used as rootstock whilst others are continuously being added to the list. Criteria used for this selection include: ease of budding, vigor, pests and disease tolerance or resis-

tance, adaptability to soil conditions (saline, calcareous, water-logged, etc.), the effect on scion (fruit size, fruit quality etc.) and other desirable or undesirable features. The selection of any of these, in particular as a rootstock, must be made on the basis of presence of the greatest number of desirable characteristics, in keeping with the requirements of the orchard in which the tree will grow. Table 2 presents the performance of a number of rootstocks as nursery plants. Table 3 presents the response of different rootstocks under different conditions.

Once the rootstock has been selected, the collection of fruit for seed must be done only from the select trees in order to ensure that the seeds are not contaminated, and that they reflect to the characteristics of the rootstock species chosen. As a general rule, the fruit for seed, must be picked directly from the tree. Fruit which have fallen to the ground, are more subject to brown-rot and/or other fungal infections that may later contaminate the whole seedbed. When possible, mature fruit should be picked from vigorous trees, which are 10 years old or more, and most importantly from those free of pests and/or diseases of economic importance.

After harvest, the fruit should be transported to the nursery within the shortest possible time. Avoid leaving the fruit directly exposed to the sunlight and/or where water may accumulate, since fruits under such conditions are more susceptible to disease infection.

**Table 2. Performance of different rootstock species as nursery plants**

Rootstock	Germination	Nucellar Embryony	Vigor	Susceptibility Diseases	Thorns	Ease of budding
Rough Lemon	Good	High	Low	anthracnose scab, foot rot	Thorny	Low branches make it difficult but easy to "take".
Sour Orange	Good	High	Good	Scab	Very	Good (ex-thorns)
Cleopatra Mandarin	Good	High	Good	None	Few	Good, but may be hard to force.
Sweet Orange	Good	Generally high-varies	Intermed.	Foot rot	Intermed.	Good
Poncirus trifoliata	Good	Very high	Intermed.	None	Very	Good (ex-thorns)
Carrizo Citrange	Good	High	Good	None (ex-psorosis by seed)	Intermed.	Good
Troyer Citrange	Good	High	Good	None	Intermed.	Good
Sweet Limes	Good	High	Good	None	Intermed.	Good

Source: Adapted from Krezdorn, A. and L. Jackson. 1973

Table 3. Performance of different species as citrus rootstock

Rootstock	Tristeza	Exocortis	Xyloporosis	Resistance to Gummosis (Foot Rot)	Resistance to Drought	Indicated for Soils	Indicated for Species	Quality of the Fruit
Sour Orange	S	T	T	H	M	Heavy	All	H
Swingle Citrumelo	R	S	T	H	M	Light & Heavy	All but Lemons	H
Carrizo Citrange	R	S	T	H	L	" " "	All but Eureka lemons	H
Carrizo Morton	T*	S	T	H	L	" " "	All	H
Citrus Volkameriana	T	T	M	M	H	" " "	All but some Oranges	L
Rough Lemon	T	T	T	L	M	Light	All but some Oranges	L
Rangpur Lime	T	S	S	L	H	Light	All	L-M
Sunki Mandarin	T	T	T	M	M-H	Light & Medium	All	M
Cleopatra Mandarin	T	T	S	M	L	" " "	All but late Oranges	M
Orlando Tangelo	T	T	S	M	L	" " "	All	M
Citrus Taiwanica	T*	T	T	M	L	" " "	All	M
Sweet Orange	T	T	T	L	L	Light	All	M

SOURCE: Adapted from Saliba, A.A., 1977

\*Show Wood Pitting

Legend: S = SUSCEPTIBLE      H = HIGH  
 T = TOLERABLE                M = MEDIUM  
 R = RESISTANCE               L = LOW

### Extraction and Treatment of the Seeds

The extraction of seeds from the fruit must be done within 1 or 2 days after harvest. Waiting for a longer period, especially if some of the fruits rot, increases the chances of contamination by pathogens that may later infect the seed-bed.

A shallow cut (about 1 cm deep) is done through the rind and approximately around the centre of the fruit (Fig. 3). The two halves are then twisted, and separated. A deeper cut will damage some of the seeds. These would then have to be discarded. The cut fruit is then squeezed into a sieve to collect the seeds. If large amounts of fruit are to be squeezed, a hand extractor or some low-speed mechanical extractors would be helpful.

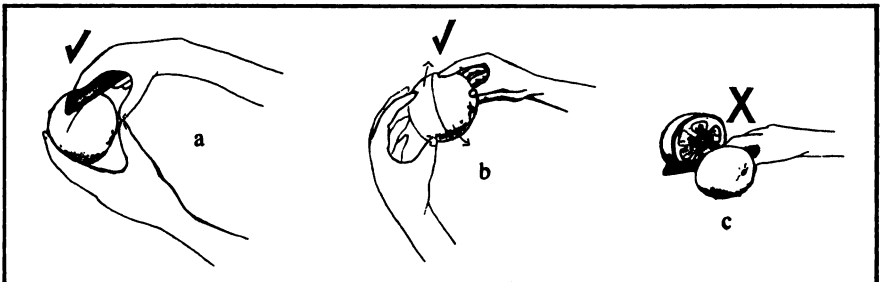


FIG 3. When cutting the citrus fruit for extraction of the seeds, a shallow cut is made through the rind around the centre of the fruit (a), The two halves are then twisted and separated. (b). The fruit should not be completely cut across the centre as shown in (c), otherwise many seeds will be cut in pieces.

The seeds remaining in the sieve are then washed free of the pulp. A preliminary selection of the best seeds based on their potential viability may be done at this time, by placing the seeds in water. The undeveloped seeds and any remaining pulp will float, these are discarded. The remaining seeds are then immersed in hot water (52°C) for 10 minutes, continuously agitating to avoid the seeds coming into contact with the bottom of the container, which is usually hotter. This treatment is effective and ensures elimination of any spores of Phytophthora citrophthora and P. parasitica, but it has little or no effect on the viability of the seeds. The seeds are then spread over newspaper, or even better, over open screen boxes. They are then left to dry in the dark for no more than 24 hours. At the end of this time, it is advisable to treat the seeds with a fungicide to reduce, among other things, the possibility of mould infestation. Some of the most common chemicals used are Captan, Maneb, Hydroxyquinoline Sulfate and Arasan (sarasan). Some of these chemicals also prevent albinism\* which is often found in seedlings growing in the seedbed.

### Seed Storage

As in the case of all seeds, it is ideal to plant them soon after they are extracted from the fruit, but since this is not always practicable, the seeds must be kept in the best possible conditions so as to guarantee a high germination percentage. Here are some hints which will help to achieve this goal:

- Do not allow the seed to dry out. A common mistake is to leave extracted seed to dry for several days in the dark before planting or storage. The germination percentage of the citrus seed will drop sharply if the moisture content falls below 70 per cent, something which could easily happen in this region with a hot tropical climate. It is inadvisable to leave seeds drying for more than 24 hours after extraction.
- Treat the seeds with an effective fungicide in addition to the hot-water treatment, whether planting immediately or storing the seeds.
- Use a container which prevents further loss of moisture, yet does not interfere with the gas exchange. Polythene bags sealed with rubberbands are recommended, especially when seeds are to be stored at a cool temperature. The use of paper bags should be limited to conditions where periods of very short storage are required, and in rooms where both the temperature and the humidity are high.
- A cool room refrigerator should be used when seeds are to be stored for prolonged periods. The ideal temperature for storage of citrus seeds range from 7–10°C. The germination percentage declines when storage temperature is over 12°C. The vegetable compartment in most refrigerators is usually a good place for storing citrus seeds. If well kept, seeds of most citrus can be successfully stored for

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\*Seedlings lacking chlorophyl in various amounts

periods as long as 8 months without significant loss of viability. Periodic viability testing of the germination potential of the seeds in storage, is advisable. This can be done by 3 methods:

- 1) **The common germination test:** Take 10 seeds from each batch and place them on a damp filter paper in a petri dish. Without overwatering, add sufficient water every day if necessary. Check for germination after 12 but before 35 days.
  
- 2) **The Seline – indigo carmine test**  
Peel 10 seeds and apply the selineite–indigo carmine solution to them: If a red color develops this means that the tissues are still alive. A blue color, indicates that the tissues are dead.
  
- 3) **The TTC test:** Peel 10 seeds and apply a drop of 2, 3, 5 triphenyl-tetrazolium chloride (TTC). If the tissues are dead the seeds will remain a natural color. If they are alive, the enzyme present in the tissue will react with the TTC and form an insoluble red dye.

## Planting the Seed

Under tropical conditions the season is not normally a limiting factor for planting; the seeds can be planted at any time during the year. However, in some regions where the wet season is prolonged, and heavy rainfall is frequent or almost continuous, planting during the dry season reduces the incidence of disease infection. At all costs, the medium on the seedbed should be disinfected (Table 1) to reduce pest and disease damage, and weed competition. Planting of the seeds can be done by several methods:

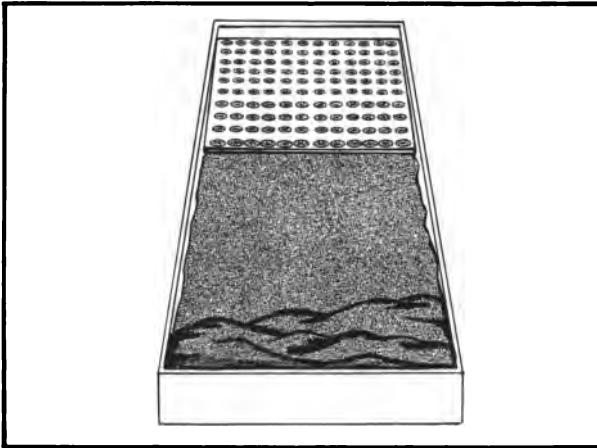
- a) Broadcast on the bed
- b) In furrows
- c) In rows using a perforated board.

**Broadcast:** Scatter the seeds over the medium. Care should be taken to achieve an even distribution over the seedbed. Cover the entire bed with a 2 – 2.5cm ( $\frac{3}{4}$  to 1 inch) layer of the medium (clean river sand, peat moss or spagnum moss are also recommended).

**In furrows:** Parallel furrows, 2.5cm (1") deep and 10cm (4 inches) apart are marked with the help of a guide. The seeds are inside the furrow. The latter system requires the removal of seeds where they are too thickly spread. The furrows are then covered with the same medium or may be filled with river sand, peatmoss or spagnum moss if available.

**Planting by perforated board:** A plywood or hard plastic template of 1m<sup>2</sup>\* is prepared by drilling holes of 1.25cm (½ inch) and 2.5cm (1") apart in rows. Each row is then separated by 8–10cms (3.24 inches). A layer (2.5cm – 1 inch) of the medium in the seedbed is removed, and the surface levelled. The template is placed over the medium on the bed and a seed placed in each hole (Fig. 4). After all the holes have been supplied, the template can be raised, leaving the seeds in ordered rows. Cover the seeds with the medium previously removed, gently compacting the medium over the seeds, using a piece of plywood, and repeat the procedure until the rest of the bed is completed.

One modification of the method is the use of a board with pegs rather than holes. When the board is pressed against the medium the marked holes appear and the seed is sown in each hole. In both cases select seeds have to be used to guarantee maximum germination.



**FIG 4.** When planting the seeds with a perforated board; a) Remove or set apart a layer of approximately 2.5cms (1 inch) of the soil media, b) Place the board at the upper end of the seed bed, c) Place a previously selected citrus seed in each hole, d) Carefully remove the board and the seeds will appear in rows. e) Continue to plant the rest of the bed in the same manner. As the board is removed replace the layer of soil media to cover the seeds.

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\*The dimension depends on the width of the seedbed since this would allow the board to be placed inside the bed.

## Number of Seeds to be used

The number and size of seeds varies considerably, for the same tree, with the species of citrus, with the location and sometimes even from year to year. On an average, rough lemon, sweet oranges and sour oranges have from 15 to 25 seeds per fruit, citranges (troyer, carrizo, etc) 10 to 15 seeds Poncirus trifoliata 25 to 40 and macrophylla 25 – 30 seeds per fruit.

Table 4 presents the approximate number of seeds per quart or litre of different species of rootstock, as indicated by many experienced nursery men.

Table 4. Number of seeds per quart or litre for different species of rootstock.

Rootstock	Seeds per Quart Or Litre
Trifoliata Orange	2,000 – 3,000
Grapefruit	2,200 – 2,500
Sweet Orange	2,200 – 2,800
Alemow ( <u>Citrus macrophylla</u> )	4,500 – 5,500
Sour Orange	2,200 – 2,800
Troyer citrange	2,400 – 2,600
Rangpur lime	3,000 – 3,500
Rough Lemon	5,000 – 7,000
West Indian Lime	6,000 – 8,000
Cleopatra mandarin	5,000 – 6,000

Source: The Citrus Industry. Volume III page 3. Walter Reuther ed. University of California, Division of Agricultural Sciences 1973.

Most citrus species used as rootstocks are polyembryonic. Often producing 2 and 3 seedlings from one seed. Theoretically therefore, we should expect more seedlings than the number of seeds planted. Since however some seeds fail to germinate and many seedlings have to be discarded, as a general rule we should plant 2 to 3 times as many seeds as the number of seedlings required for budding.

## Care for the Seedbed

After planting, it is advisable to protect the seedbed from destructive environmental factors in order to facilitate germination and promote good growth of the seedlings. This is especially important in hot areas, areas with high wind intensity and areas where heavy rainfall occurs. During the hot dry season, the use of a frame covered at the top with a piece of saran netting reduces the percentage of light reaching the bed, and maintains a cooler micro environment. If winds are



high in that particular area, protection must be provided to avoid rapid transpiration and the bending of the seedlings. This can be obtained by the use of live windbreaks and/or by placing the saran netting to cover both the top and the sides of the seedbed (fig. 5).

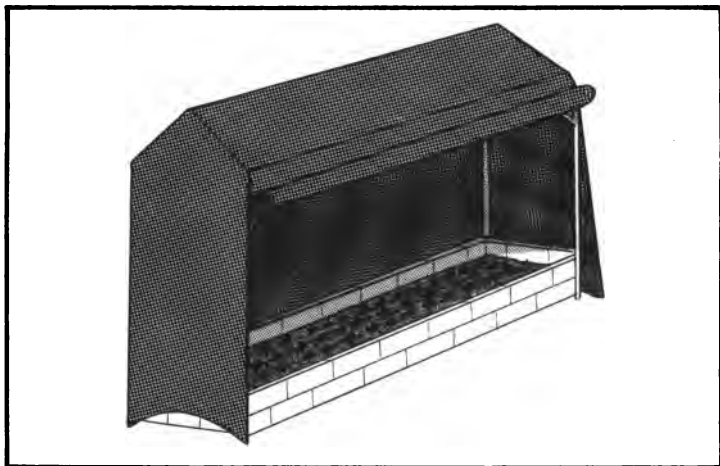


FIG 5. In hot areas and particularly areas with high wind intensity, the use of saran net at the top and at the sides of the seedbed is recommended. As the seedlings begin to grow the shade is gradually removed, first from the sides and finally from the top.

### Cultural Practices

**Fertilization:** To recommend a proper fertilization of the citrus seedbed knowledge of the fertility of the seedbed medium is essential. An analysis of this medium would determine the most appropriate formula and quantity to be applied. In general, nitrogen is the most commonly deficient element. In some areas, the addition of phosphorus and/or potash may also be essential. When fumigants are used to treat the soil media, zinc, copper and phosphorus are commonly found to be deficient.

If an analysis of the medium is not available, when preparing the medium the following process is generally recommended. First, add  $5\text{kg}/\text{m}^3$  of the formula 15-15-15; then when most of the seeds have germinated, apply  $1\text{kg}/10\text{m}^2$  of ammonium sulphate; repeat within 3 to 4 weeks. In both cases, the ammonium sulphate must be completely dissolved with enough water, to prevent the burning of the leaves of the seedlings. Avoid the use of urea unless a very low (less than 2%) biuret urea is available.

**Irrigation:** Seedbed moisture undoubtedly constitutes the most important cultural practice for achieving successful germination and seedling growth. The amount of water used and its frequency of application should be such as to guarantee that the soil surrounding the seeds or the seedlings neither dries out, nor becomes over saturated.

Germinating seeds are rapidly killed by drought while excessive water promotes diseases and rots the seeds. Frequent and light watering is preferred to widely-spaced and heavy watering. The use of tensiometers placed in the rooting area of the seedbed provides a good means of properly controlling the moisture levels, by helping to determine when watering is needed. Under average conditions, from planting to seed germination, irrigation is recommended twice a day, and once a day thereafter.

### **Weed control**

In most cases sterilization of the medium kills most of the weed seeds. In general, weeds should be removed from the seedbed to eliminate unfavourable competition with the seedlings. The total suppression of perennial weeds is important for a successful seedbed, and care should be taken to achieve this prior to planting the citrus seeds.

### **Pest and disease control**

The most common disease found in citrus seedbeds is damping-off, which is caused by a fungus such as Rhizoctonia, Phytophthora or Sclerotinia. Anthracnose (Colletotrichum sp.) and scab (Sphaceloma sp.) are sometimes also serious problems. Several insects (aphids, beetles, etc) and mites, are also common pests of citrus seedbeds. In general, the best control is achieved by preventive measures. When the medium is disinfected, the incidence of seedbed pests and diseases is minimized. Frequent checks of the seedbed are however needed to avoid serious plant losses, since the build up could be so rapid that natural biological control may not be effective. Control treatment should start as soon as the pest or diseases are observed. Many systemic and non-systemic products are available for the control of these pests and diseases. Their use depends on the type of insect or fungi found.

## **TRANSPLANTING THE ROOTSTOCK**

**Digging the seedlings:** Citrus seedlings should be dug on the same day, or not more than one day before they are transplanted. The time the seedling remains in the seedbed depends on several factors:

- a) Condition and care of the seedbed: Seedlings growing in a good medium and receiving proper irrigation, weed control, fertilization, and pest and disease control, will grow faster and be ready in a shorter period of time.
- b) The location: It is well known that to reach the desired stage, seedlings growing in places with cold seasons require almost twice the time specified for those grown in tropical climates where growth is continuous.

- c) **The species used:** There is a marked difference in the growth of certain species as compared with others. Macrophylla, Cleo, Sour Orange, Troyer and Sweet limes for example, have a more vigorous growth than most other stocks. The performance of the different citrus species while in the seedbed determines how soon the particular seedlings can be transplanted.
- d) **Where the seedlings are to be transplanted:** Citrus seedlings may be transplanted in beds, in levelled soil or in containers. The size chosen for transplanting and the subsequent time they must remain in the seedbed depends on the system used. In general, the time, in places with tropical climate, ranges from 3 to 12 months, and the size may vary from 15 to 60cms.

When the seedlings are being dug, the seedbed should be moist to avoid root loss. A spade or fork may be used to lift the seedlings, which are pulled out from the medium, taking care to minimize root damage. In cases where the seedlings have been growing in the beds for a relatively long time (6 months or more), the tap root develops to such an extent that they have to be cut. This normally occurs with seedlings left in the seedbed for prolonged periods before they are to be transplanted in beds, or plain leveled soil. In these cases a spade is used to cut the tap roots approximately 20cms below ground level. The spades and any other tools used should be disinfected each time before use with sodium hypochloride i.e. bleach. The seedlings which are dug are then dealt with in the following manner:

- 1) **Discard:**
  - a) seedlings with diseases at the top or at the root.
  - b) seedlings with severe physical damage.
  - c) seedlings with deformed roots (bench root).
- 2) **Separate** the remaining seedlings into 3 groups according to the size, into small, medium and large. The small and large size seedlings have a sexual origin whereas the medium ones are of an asexual origin (Apomitic). Whenever possible, it is preferable to keep only medium sized seedlings since only these, due to their asexual origin guarantee the reproduction of the characteristics of the specific species.

However, in practice, the limitation of resources often makes it necessary to use available stocks. In this case each of these groups should be transplanted in different blocks.

The balance between the root and aerial part of the seedling top is also important. It often proves difficult to accommodate large root systems in the holes prepared

for transplanting. This often makes it necessary to trim parts of the roots or aerial system. Any tool used for this purpose should be sterilized in sodium hypochloride each time before use.

After removing the seedlings from the seedbed, and during the period while the seedlings are waiting to be transplanted, their roots should be protected from desiccation. A common method of doing this is by placing them in a mud made of sterilized soil and water. The seedlings should be placed in a pan with the root system immersed in this mud. Damp burlap, shavings, peatmoss, and sphagnum moss can also be used. In general, leaving the seedlings exposed to full sunlight should be avoided.

### **Transplanting in containers**

Plastic (polyethylene) bags, cans or hard plastic are some of the most common containers used in the process of propagating citrus trees. In our conditions black plastic (polyethylene) bags 35cm (high) x 20cm (wide) and base of 5cm (14" x 8" x 2"), with 0.20mm girth, are very suitable for the commercial production of citrus plants at the nursery. The medium in the container could be the same as that of the seedbed, but in general, a soil-sand-manure mixture is the most common and economic. As in the case of the seedbed, the medium should guarantee good internal drainage, yet retain the necessary moisture for good growth. Disinfection of the medium is the same as that described for the seedbed medium. Sometimes the medium may be disinfected after plastic bags have been filled and arranged in rows. In this case, the sterilizing chemicals are applied to the individual bag.

For propagation in containers, seedlings 10–12 weeks old are known to give the best results. With the help of a long-necked bottle or a piece of stick, a hole 10cm deep is made in the medium of each container. A single seedling is set per hole. If the root system of the seedling is too large, the bottom should be cut to accommodate it in the hole. Once more, be sure to disinfect the tools with sodium hypochloride. After setting the seedling in the hole, press the medium gently around the plant and apply water. All air pockets should be eliminated by this operation, to guarantee a rapid response in growth.

### **Transplanting in beds**

Citrus trees propagated\* in beds can either be placed in containers to complete growth before going to the field, or they can be transplanted bare-rooted into the field. The latter method is only recommended when containers are not available at the time the seedlings are ready to be transplanted. Raised beds for barerooted plants are constructed in the same way as seedbeds are. Then beds (0.25 x 1 x 10m) can be made on the ground using soil, sand and manure, and should be spaced approximately 0.40m apart. Seedlings are set staggered, in triangles 0.30m (base) x 0.30m (high) when they are 5–6 months old.

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\*This refers to both budded and trained.

## **Transplanting in the ground**

Most plants to be balled for later transplanting to the field are propagated directly in levelled soil.

This system is also used for transplanting barerooted plants, especially when large numbers of trees are to be propagated. It also permits the mechanization of the extraction of the trees once they are ready. Since the soil must be light in texture and structure for barerooted plants, sandy or loamy soils are highly recommended. In general, the soil is ploughed and harrowed, and seedlings are set in double rows.

Once transplanted, the seedlings must be kept in the best possible condition to guarantee rapid growth and good health. Bi-monthly fertilization with 2 g/plant of 15-15-15, will normally help to maintain a good rate of growth of the seedlings, and will reduce the time from germination to the budding stage. Irrigation, under normal conditions should be performed every day, except during the rainy season. The use of sprinklers considerably reduces the cost of this task.

Seedlings should be periodically inspected for pests and diseases and treatments should be applied as early as possible, since a build up of these microorganisms could threaten the majority of the plants in the nursery. A preventive spray programme should be designed and applied to keep the population of these organisms to a minimum. Preventive spraying every 2-3 weeks, should be a common practice at all citrus nurseries. Be sure to include a broad-spectrum insecticide, a miticide, and a fungicide in each spray, and foliar fertilizer rich in minor elements, to prevent microelement deficiency. During the rainy season, a sticker should also be added.

Weeds should be manually controlled unless one has experience with some of the herbicides available for this purpose. A continuous suppression of the weeds eliminates the competition they could present to the citrus plant for light, water and nutrients, and would eradicate possible hosts for pests and diseases.

The seedlings should develop clear, straight trunks to facilitate budding. As part of the programme of care for the seedlings, suckers and small branches below the height where the buds are to be set, should be removed. The continuous sterilization of the tools with sodium hypochloride is always recommended, to avoid virus contamination.

## **BUDDING THE ROOTSTOCK**

The time needed for a rootstock to be ready for budding, depends on a number of factors. These include the care, the location, the species and the system of propagation to be used. The transplant of seedlings to containers e.g. plastic bags is done while these are very young (10-12 weeks), and normally takes a

long time to be ready for budding (5 to 8 months). Seedlings transplanted in beds and/or levelled ground, normally already have the thickness (pencil-sized or 6mm – ¼ inches) to hold the bud. Soon after they overcome the shock of transplanting, they resume growth and can be budded within 1.5 to 2 months.

The height recommended for budding, varies with the location. The type of soil where the citrus tree will definitely be planted, is the most important factor taken into consideration when choosing the height of budding. Other factors, some of which are closely associated with the type of soil, such as the potential presence of soil-borne fungi, susceptibility of the scion to these and other problems, water-logging, high wind intensity, temperature, etc. are also considered. In general, higher budding is recommended for heavier soils. For sandy soils, low budding (2"/5cm – 5"/12cm) is standard practice, but for clay soils, high budding (over 30cm – 12 inches) is always recommended. Evidence has shown that under some conditions, extremely high budding (over 60cm or 24 inches) affects the productivity of the citrus plant. Additionally, the cost of production of a citrus tree at the nursery is increased with the height of budding due to the longer period required by the rootstock to develop the minimum girth at the budding point. In general, budding above 50cm (20 inches) is not recommended.

### **Selection of the budwood**

This is one of the most important steps, in the establishment of a citrus orchard with healthy, productive, and high quality trees.

It should always be remembered that, in the asexual propagation of plants, "What you propagate is what you get". Therefore, in the selection of trees from which the budwood is to be taken, one has to ensure that these trees meet the requirements for the future orchard. Some of the most important aspects to consider when selecting a citrus tree for budwood, are the following:

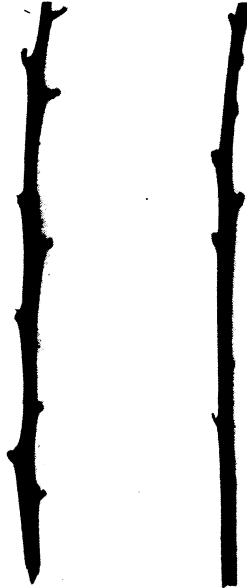
- a) The primary choice should be virus-free plants in budwood registration and certification programmes.
- b) Be sure that the characteristics of the tree corresponds to the cultivar requested.
- c) Avoid taking budwood from plants which show abnormal growth, or abnormal fruits.
- d) Avoid taking budwood from plants with rapid or vigorous growth to reduce the probability of propagating undesirable mutations.
- e) Only select trees with a record of good yields, and proven high quality fruits.
- f) Avoid choosing any plant showing symptoms of diseases.
- g) Give preference of adult trees (10 years and older) and reject any thorny budwood.

There are two types of citrus budwood: The **round** budwood, from hardened twigs, which is usually preferred by propagators, and the **“angled”** budwood, which comes from less mature twigs (pict.1). The latter is more used in the **“microbudding”** of small citrus seedlings.

One should remember that the propagation tool e.g. knife, secateurs, must always be sterilized in sodium hypochloride every time the propagator moves from one tree to another.

The budwood should be used immediately after it is collected, and must not be allowed to dry out.

If storage is required, prepare the budwood as normal, clipping off leaves and thorns. The budwood should then be cut in appropriate lengths (15 to 20cm – 6 to 8 inches), arranged in small bundles, labelled, and sealed in polythene bags. They should then be put in a refrigerator at 10 to 13°C. If a refrigerator is not available, the budsticks should be kept in damp\* peatmoss, vermiculite or sterilized sawdust, and maintained in a cool, dark area. Some experiences have shown, that under optimal conditions, citrus budsticks can be kept for 3 months and still remain in good condition for budding.



**PICT 1. TWO TYPES OF CITRUS BUDWOOD.** The **“Round”** Budwood, usually preferred by propagators when budding trees of all citrus species, come from mature twigs. The **“Angled”** budwood, from less mature twigs, is more commonly used when microbudding small seedlings.

### **The budding process**

Worldwide, three major methods are used for budding citrus. T-budding, chip-budding and micro-budding. The last method mentioned can be considered

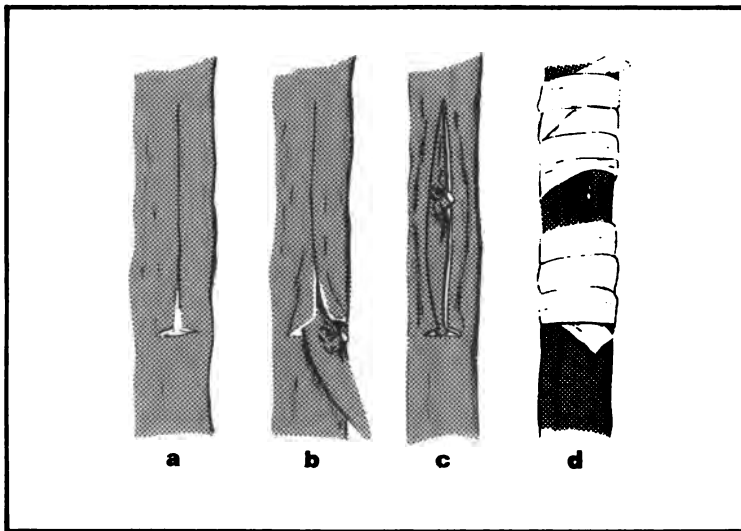
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\*Note that moulds and fungi will easily develop if the storage material is too wet.

an adaption of the first two, since the only difference is that very small buds are budded on smaller, thinner stocks. The process is however, basically the same.

“T” budding (Fig. 6) could either be the normal ‘T’ or inverted ‘T’ type. This method consists of making an incision in the bark of the rootstock at the selected height, in a ‘T’ shape or ‘L’ (Fig. 6a). A shield-shaped bud (1.5 to 2cm long) is sliced from the budstick with a very sharp knife. The two sides of the bark in the stock are gently opened to permit the insertion of the shield bud (Fig. 6b).

The bud is then pressed inside until its sides are completely covered by the bark (Fig. 6c). Immediately following, the bark should be wrapped with a piece of wrapping plastic (Fig. 6d). Some propagators prefer to leave the “bud-eye” free, while others prefer to cover it completely. For the ‘T’ method to be successful, the bark must slip easily.

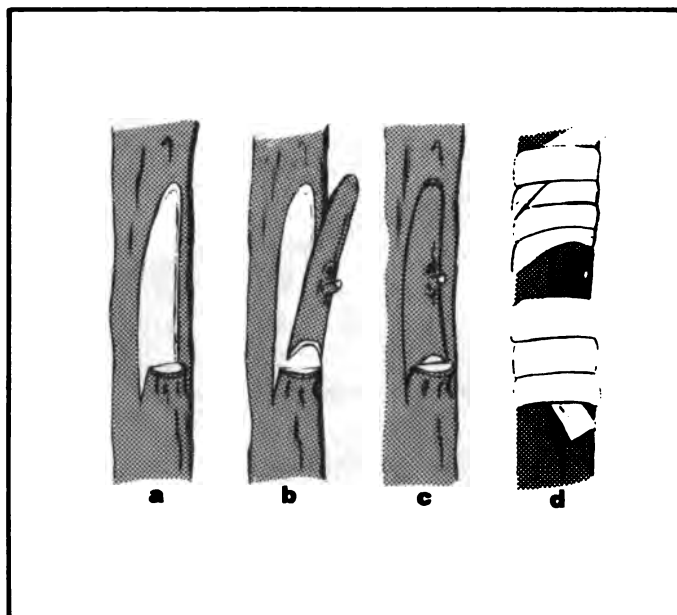


**FIG 6. The “T” BUDDING METHOD.** a) an incision is made in the shape of an inverted “T” in the bark with a sharp knife. b) The two sides of the bark are gently lifted and the shield-shaped bud pushed inside. c) The bud is fitted inside the bark. d) A piece of plastic is wrapped from the bottom upward around the stock, leaving the bud-eye free.

The wrapping should be performed from the bottom upwards, to avoid the penetration of water through the edges. Several types of material of different colors are used for wrapping, but the most common is the clear polyvinyl chloride tape. The clear tape, as opposed to the colored, allows one to see at any time whether the bud is still alive.



**“Chip” budding (Fig. 7)** is especially important when budding old stock, or when, for some other reason, the bark does not slip easily. The method is very similar to **“patch” budding**, and the bud is sliced off from the budstick as in **“T” budding**. The basic difference with the **“patch” method** is that for **“chip” budding**, cuts are made to form a lip in the budstick and on the stock (figs. 7a, 7b). A section of bark of the same shape and size as the sliced bud, is cut from the stock so that a lip is also formed in the lower end of the stock to hold the bud in place (Fig. 7c). Wrapping should then be performed as in the previous case (Fig. 7d).



**FIG 7. THE “CHIP” BUDDING METHOD.** a) A section of the bark is sliced off the stock to form a lip at the bottom. b) A chip bud of the same size and shape is sliced from the budstick. c) The chip bud is set so that the lip made in the stock will hold the bud in place. d) Wrapping around the stock from the bottom upward finally secures the chip bud in place.

In **“microbudding”**, the rootstock is normally still young and thin. The microbudding process will be done, depending on the size and thickness of the stock, either by the **“T”** or **“chip”** method. The **“chip”** method allows the use of thinner, younger stocks. Some propagators prefer to use well-matured, but tiny, buds, in small budsticks. However, since the rootstock is also young, good results are obtained using the angled budwood which is also young and permits tiny pieces with small buds, to be cut. The wrapping process is the same as before, except that in this instance narrower pieces of plastic are needed. This method should not be confused with **“apical meristem micrografting”** which is used to obtain virus free plants.

In “microbudding”, the use of leach tube containers is recommended, since these allow a higher number of plants to be kept per unit area, as compared with other containers (Pict.2). These containers also facilitate citrus propagation from seed to budding, and budded plants can be kept in them for a very long time.

In all three methods, a piece of stick the length of the selected height of budding, is useful for marking the height where the bud is to be placed (Pict. 3). This system helps to standardize the height of budding throughout the nursery.



**PICT 2.** The use of leach tubes, for budding, allows a higher population density than the traditional container e.g. plastic bags (98 to 6). The use of these containers is highly recommended for microbudding. It facilitates citrus propagation from seed to budding and the budded plants can be kept in them for a very long time.

### **Unwrapping and forcing**

Under tropical conditions, unwrapping is carried out from 12 to 30 days after budding. Normally, the younger the stock, the shorter the time required. After unwrapping, if the bud is alive, the stock is bent or cut to force the bud to grow.

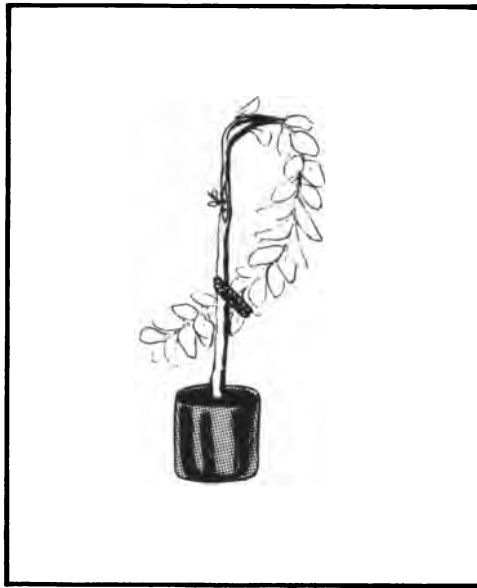
Three different systems are used to achieve this:

a) **Looping without cutting:** In the Caribbean and Latin America, this is the least used system. It consists of bending the stock 10cm (4 inches) above the bud and keeping it in a bent position by tying it to the trunk (Fig. 8). As soon as the bud starts to grow, a partial or definite cut is done near the bud union.

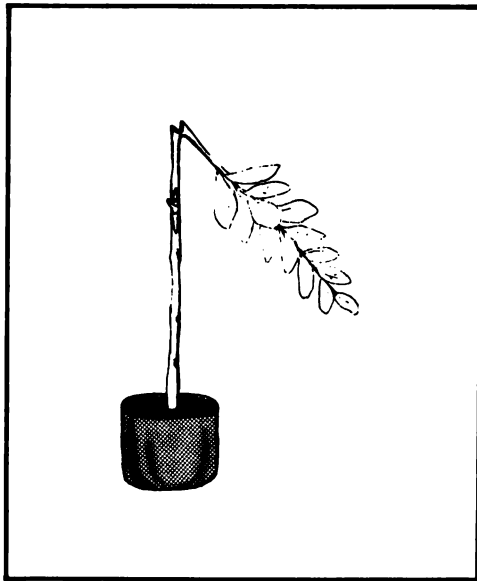
b) **Looping and cut off:** This system consists of partially cutting the rootstock stem 10 to 15cm (4 – 6 inches) above the bud, and then bending the top of the rootstock (Fig. 9). The rest of the stock is cut off at a later time when the bud grows out. This system gives good results for balled plants when propagating on plants already growing in the soil.



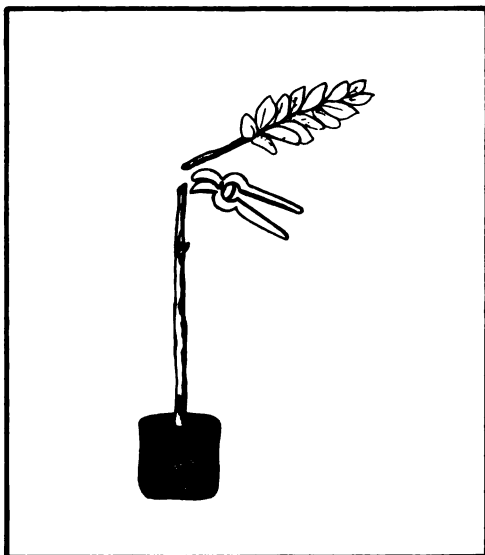
**PICT 3.** A piece of stick, the length of the desired budding height, is useful in helping the budder to standardize the specific height at which the stock is budded.



**FIG 8. FORCING THE BUD BY LOOPING.** The stock is bent 7 to 12cms above the bud and kept bent by tying it to the trunk of the stock.



**FIG 9. FORCING BY LOOPING AND PARTIAL CUT OFF.** The rootstock is partially cut 10 to 15cm above the bud. The top of the rootstock is then bent down. This piece of the rootstock is eventually cut off completely when the bud grows out.



**FIG 10. FORCING BY COMPLETE CUT OFF.** The rootstock is cut off in a slant (at once) 10cm above the bud.

c) **Complete cut off:** In the Caribbean region, this system is the most widely used for forcing, especially when citrus is propagated in plastic bags. Modifications of this system exist. Most of them are related to the time and the height where the first cut is made. In general, cutting 10cm above the bud is recommended, as soon as the unwrapping shows the bud to be still alive (Fig.10). A healing compound e.g. pruning paint may be used to prevent dieback of the stub.

### **TRAINING THE BUDLINE**

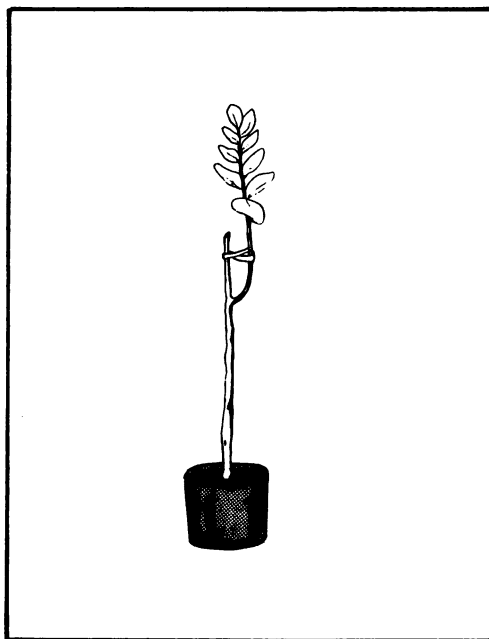
Citrus should be trained in the nursery to form the trunk and scaffold branches in such a way, that the farmers will have to do a minimum amount of work in the field. Allowing the plants a free growth in the nursery, often results in problems later on. In the nursery, plants with free growth develop low, bent shoots, which may easily break at the bud/graft union. Also, the multiple shoots which develop, lengthen the time for the plant to reach the proper height before release. Very often, the low, multiple shoots, will have to be pruned later by an inexperienced labourer in the field in which case the plant can seriously be damaged, or the branches can be so low as to make all cultural practices involving labour difficult. These same low branches will produce fruit which because of their weight, will cause the branches to touch the soil and lead not only to spoilage of the fruit, but also to facilitate disease infections.

The initial training of the budling consists in allowing only one shoot to develop from the bud, cutting off any other that may appear. All shoots coming

from the rootstock are also to be eliminated. The new shoot is tied to the “stub” previously left in the rootstock over the bud (Fig.11). This will force the shoot to grow fast and straight. When this shoot is about 15 to 20cms (6 to 8 inches), and presents a mature aspect, the “stub” is cut off in a slant, and treated with a healing product i.e. pruning paint. A support is then used to continue the training of the budling (Pict.4). These supports can be made of different materials. Iron or steel rods, hard plastic, pine wood, red wood, cypress and bamboo sticks, with lengths varying from 1 to 1.20m (40 to 48 inches), are the most common supports used. 3/16” to 1/4” steel rods are probably the best. Even though initial investment is high, these tend to last for long periods. These should be painted to prevent rust. All other supports can be safely used depending on their availability.

The shoot is tied to the support as it grows. The ties should neither be loose nor should they be so tight as to injure the bark. All side shoots are eliminated as they appear. To avoid possible contamination, it is necessary to disinfect the tools with chlorox and rinse them with water, each time the trainer moves from one tree to another.

Training the plants at the nursery may result in two main tree-forms: “Headed” trees in which free lateral branches are induced in the nursery and “whip”\* trees which have no lateral branches (Pict. 5).



**FIG 11.** The “budling” is initially trained by allowing only one shoot to develop and keeping it straight by tying to the “stub” previously left above the bud.

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\*Also known as “cane”

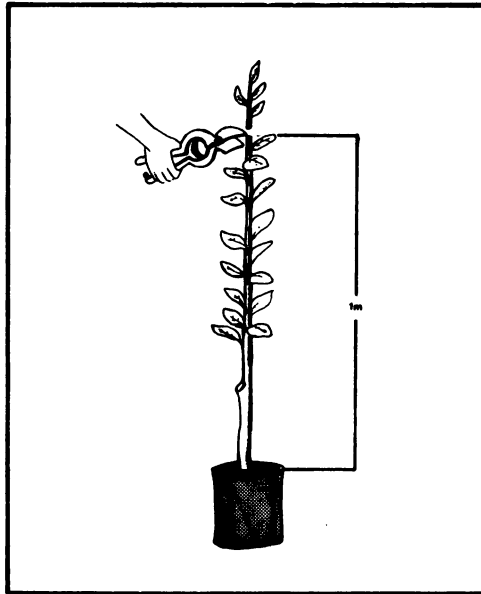


**PICT 4.** A 'Tapener' is very useful when "training" citrus trees to a "whip" shape. The instrument speeds up the process of tying the plant to the support.



**PICT 5.** THE "HEADED" AND THE "WHIP" OR "CANE" CITRUS TREES. The headed tree has lower branches due to free growth in the nursery. In the "whip" tree, the development of lateral branches are normally not allowed until the plant is transplanted in the field. In some cases, 3 to 5 branches may be induced at a specific height prior to transplanting.

The advantage of the “headed” trees is that they leave the nursery with the proper number of the definite scaffold branches, while in the case of the “whip” trees, these branches will be formed in the field. The advantage of the “whip” form, is that it is a lot easier to store and transport the trees from the nursery to the farm, and the plants require a relatively shorter preparation time. In both cases, the plant in the nursery is left to grow up to more than 1m (>40 inches) with a single trunk and is then cut back to 80 – 100cm, 32 – 40 inches (Fig.12). At this stage, the “whip” tree is ready to leave the nursery. This is what will probably be the beginning of the framework for the future canopy of the “headed” tree. Three to five well-placed branches are left to develop from the stem.



**FIG 12.** The citrus tree trained to a “whip” form is left to grow with a single trunk to more than 1m and then cut back to 80 or 100cms where three to five branches will be allowed to develop.

Fertilization, irrigation, weed control, and pest and disease control of the budling, follow the same processes described for the seedlings prior to budding.

When the citrus trees have the form and height required to leave the nursery, those propagated in plastic bags are ready to be delivered to the farmers. However, those in beds or levelled ground will have to be dug, New growths should not be present when these plants are dug, regardless of whether they are balled\* or barerooted. The practice of withholding fertilization at least one month before the digging of the plants, and watering 15 days before, helps the plant to adjust to the shock of “balling”.

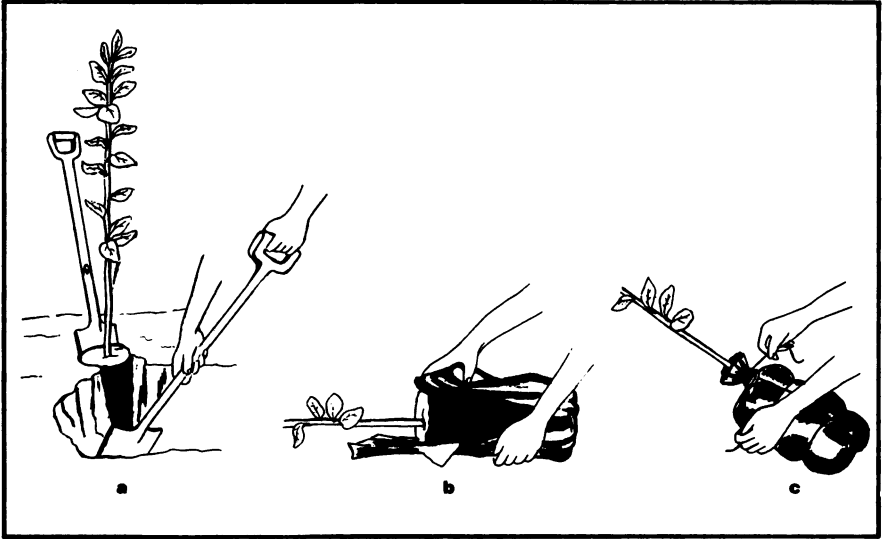
When digging the plants from the levelled ground, care should be taken to prevent extensive root damage and the drying out of the root system.

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\*A ball of soil adhering to the root.



For the balled plants, the size of the ball depends on the size of the tree and its root distribution. The larger the tree, the larger the ball needed. In normal sized trees, this ball is 20cm (8") in diameter. If a tap root has developed, digging should be done to one side of the plant and a cut made at least 30cm (12 inches) below the ground (Fig.13a). The depth of this cut is also relative to the size of the trees. Normally, if the tap root system is eliminated when the seedling is initially transplanted, the plants will develop a more lateral root system making the digging procedure easier. A curved spade about 40cms (16") long is very useful for digging balled plants.



**FIG 13. DIGGING THE "BALLED" PLANT.** a) Dig at one side of the plant and cut the taproot 30cms below ground. b) The ball of soil and roots are dug out and laid on a piece of plastic, cloth or burlap. c) The ball of soil and roots are held together by securely tying the burlap around it.

The ball of soil and the root are then wrapped and tied in paper, plastic, cloth, burlap or Jute bags to secure the soil around the root (Fig. 13b, 13c). The balled plants must be carefully handled to prevent shifting the soil in the ball, since this will tear off fragile feeder roots. The ball of soil must not be left to dry out. The sprinkling of small amounts of water from time to time, will allow the plants to remain in good condition, especially if they are to be stored for some-time before they are released. These plants should be stored in a shady place to avoid rapid transpiration which could kill them.

Barerooted plants should be protected immediately after digging to prevent the root system from drying out. The "whip" system is recommended in most cases for balled and bare-rooted plants, in which case the foliage is partially or totally eliminated. This final operation depends on the humidity of the region where the barerooted trees are to be planted.

## **RELEASE OF CITRUS TREES BY THE NURSERY**

Each nursery should define "standards" for the release of citrus trees. These "standards" should guarantee the purity, health, good yield and quality potential of the cultivar being released.

The parameters or factors describing the "standards" vary from one location to the other, but in general, the following factors should be considered.

- a) Destination of the final plant (region and/or location where the trees are to be planted and their ecological characteristics).
- b) Species and cultivars to be propagated.
- c) Source of budwood.
- d) Species used as rootstock.
- e) Source of seeds for rootstock.
- f) Propagation method.
- g) Height of budding and/or grafting.
- h) Training system ("whip", "headed" or "free" growth).
- i) Number and position of scaffold branches.
- j) Delivery criteria e.g. general appearance, health, vigour, sizes, maturity, etc.

The citrus grower should be advised to buy citrus plants only from those nurseries which have established high "standards" in the propagation of their plants.

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