MASTER'S REPORT

CITRUS ROOTSTOCKS AND PROPAGATION

Submitted by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter I

INTRODUCTION

Budding on seedling rootstocks is the general practice in propagating Citrus species, because only budding or grafting can give the advantages of having a root system which is better adapted to the soil conditions than the scion roots are (10). There are always some variant trees in a seedling orchard, and most trees are thorny when grown from seed and require much longer to come into commercial production (71).

Cuttings could be used as rootstocks for budding. However, trees from cuttings of varieties that are susceptible to gummosis (Phytophthora parasitica and Phytophthora citrophthora) are apt to suffer more damage because susceptible wood is in the soil where conditions are most favorable for gummosis instead of starting at a high bud union on a resistant rootstock (5,10).

Stocks for budding citrus varieties are obtained from seeds. Fortunately, a high percentage of seedlings can be obtained from nucellar embryos with a high degree of uniformity. Because of the predominance of nucellar embryos, seedlings of most citrus varieties are apt to be nearly as uniform as trees from cuttings. They are also more vigorous and more convenient to bud (10,59).

Rootstocks greatly influence the production and management problems of citrus orchards, and their importance should not be overlooked when planting or buying an orchard. The wrong rootstock

for a given soil type or for a particular variety can mean the difference between success and failure in an orchard operation (22,40).

Rootstocks influence vigor, longevity, cold hardiness, yield, fruit quality, and disease tolerance or resistance. Some rootstocks are superior on one or more of these qualities, but inferior on others, and none is superior on all counts. The choice of a stock, therefore, must be made for a particular stock-scion combination in a particular environmental condition (38,71).

Chapter II

CITRUS ROOTSTOCKS

The fact that some rootstocks perform better in certain soils and climates than others has been known for many years. In general, sour orange rootstocks were used on heavy, wet soils; rough lemon on light, sandy soils; and trifoliate orange or sour orange stocks in the colder areas (22,40).

Virus diseases such as tristeza, xyloporosis, and exocortis, together with increased demands for high quality fruits have complicated the rootstock problem and changed ideas as to the value of the commonly used rootstocks (7).

A satisfactory stock must be congenial with the scion budded on it. The two must form a union which permits good growth, long life, good yield and good fruit qualities of the scion variety. The stock must also have edaphic, climatic, and biotic adaptability (71).

With this in mind, it is now appropriate to point out the merits of the major rootstocks available to the citrus industry.

Rough Lemon (Citrus jambhiri Lush.)

Rough lemon is especially suited to the light, sandy, well-drained soils. It is not recommended for low, heavy, poorly-drained soils because of its susceptibility to gummosis (26,40).

Rough lemon is resistant to tristeza and xyloporosis but is susceptible to gummosis. Like all other known rootstocks, it is

subject to attack by various nematodes. However, rough lemon A and B, and clone X are tolerant to the burrowing nematode (Radopholus similis Thorne) (17,71).

Oranges budded on rough lemon stock are tolerant to quick decline, but with grapefruit tops the trees are susceptible. Lemons budded upon it are predisposed to early and heavy outbreaks of shell bark (7).

Both trees and fruits on this stock are more susceptible to cold injury than are trees on other rootstocks in common use. For this reason, rough lemon should not be used as a rootstock in cold locations (22). According to Cooper (14) all scion varieties on rough lemon stock were injured more severely during the freeze of 1962-1963 than those on other stocks.

This stock produces larger trees in shorter time than any other stock and produces heavy crops at an early age (3). Most trees on rough lemon stock are relatively short-lived. The life of the tree is shorter on heavy soils than on light sandy soils (7). Fruits from trees on rough lemon stock are poorest in quality, having thick rinds, less juice and less soluble solids than fruits from trees budded on other commonly used stocks (3,30,43).

Today, about 70% of the citrus trees in Florida are on rough lemon stock, and 62% of the nursery stock planted from 1955 to 1960 was on it (40,71).

Sour Orange (*Citrus aurantium* L.)

Sour orange has been used extensively for citrus wherever soils are low, wet, or heavy. However, it is a slow grower on light sandy soils. It is resistant to foot rot (gummosis) and xyloporosis, but is susceptible to tristeza (40,71). The tristeza virus to which sweet orange is tolerant goes from the sweet orange top into the sour orange stock and causes phloem necrosis and a resulting starvation of the stock (10). The citrus industry of Brazil was almost wiped out in the 1940's by a severe form of this virus because most trees were on sour orange (71).

Of all commonly used rootstocks, sour orange is second only to the trifoliate orange in cold hardiness. It is moderately tolerant to salt (26,40).

Varieties budded on sour orange stock produce high yields of good quality (13,40). Sweet orange trees on sour orange stock develop a bud-union disorder (63). Eureka lemons budded on sour orange stock tend to develop shell bark and decline at an early age. However, this stock can be used for lemon varieties that do not show quick decline symptoms, particularly Lisbons (7,38).

Sour orange stock is still extensively used in Florida nurseries, but is less popular than before because of its susceptibility to tristeza. About 25% of citrus trees in Florida are worked on this stock (71).

Cleopatra Tangerine (*Citrus reshni* Tanaka)

Cleopatra tangerine* is adaptable to a wide range of soils. The trees grow well in deep sandy soils as well as on wet low soils, although in the deep sandy soils the yield of young trees on it is poor and fruit size is small (3,40).

Cleopatra tangerine is resistant to tristeza, xyloporosis and gummosis, although its resistance to gummosis is less than that of sour orange. It is nearly as cold hardy as sour orange (14,71).

This stock makes good unions with all kinds of citrus scions and produces on them fruits of high quality. It is a slow grower and trees on it come into bearing a little more slowly than other stocks. It has given as good or better yields than other stocks when used for Washington navel, Valencia and Satsuma orange, March grapefruit, Eureka and Lisbon lemons (1).

Cleopatra tangerine seems to combine many of the good features of both rough lemon and sour orange. Many people think that Cleopatra tangerine is most likely to replace sour orange as a commercial stock. However, it is by no means equal to sour orange under all conditions. About 12% of the nursery trees sold in Florida from 1955 to 1960 were on this stock (40,71).

Sweet Orange (*Citrus sinensis* Osbeck)

Sweet orange is adapted to light, sandy soils and well-drained heavier soils. It is resistant to tristeza, xyloporosis

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* This stock is also called Cleopatra mandarin.

and exocortis but is susceptible to gummosis, especially on heavy, poorly-drained soils. It is more sensitive to soil salinity than sour orange but comparable to it in cold-hardiness (7,40).

Trees on this stock are larger than on sour orange, though not so large as on rough lemon. Union of this stock with all citrus scions is good but scions are delayed in coming into bearing as compared to those on rough lemon (42,71).

Trees on sweet orange are long-lived. Eureka lemons on this stock develop shell bark at a later age than on sour orange, rough lemon, and grapefruit stocks (7). Trees on this stock produce fruits of high quality, almost as good as on sour orange, but far superior to fruits on rough lemon. Fruit size on sweet orange stock is larger than on sour orange but smaller than on rough lemon (40).

There is a renewed interest in sweet orange because of the high fruit quality it produces, but Cleopatra tangerine is much more popular. In California its use is still recommended, especially on light, well-drained soils (7,71).

Trifoliate Orange (*Poncirus trifoliata* Raf.)

Trifoliate orange is well adapted to low, heavy soils. It is resistant to gummosis, tristeza, and xyloporosis but highly susceptible to exocortis (32,71). Knorr (35) reported its tolerance to nematodes.

Trifoliate orange is probably the best source of cold-hardiness among all commonly used rootstocks (14,19). It always overgrows the scion and trees are dwarfed on it. Growth is slow

in the nursery but trees on it start to bear earlier than on any other stock and produce fruits of excellent quality. Fruits of trees budded on trifoliate orange mature earlier in the season than on other rootstocks (10,68).

The yields of Valencia oranges on trifoliate stock have been equal to those on sweet orange, though the trees on trifoliate were smaller. Yields of trees on trifoliate stock are good for the tree size attained (7,40).

When exocortis-free buds are available, this stock may be used as a replacement for other stocks, especially sour orange which is susceptible to tristeza, while trifoliate is resistant to it (40).

Grapefruit (*Citrus paradisi* Macf.)

Grapefruit grows vigorously on heavy soils and is fairly tolerant to saline conditions. It is susceptible to tristeza and resistant to gummosis, but is less resistant to gummosis than sour orange (10). Lemon collapse occurs more frequently on grapefruit stock than on other stocks. Trees on it are less hardy than on sour orange (7).

This stock produces vigorous trees that are characterized by low yields and tend to develop a tendency to alternate bearing. The yields of all varieties budded on it were 15 to 30 percent less than those on sweet or sour orange stocks (7,40). Trees on this stock produce fruits of average size and of good quality, similar to those on sweet or sour orange (6).

If grapefruit is to be used as a rootstock, it should be limited to certain lemon strains that do not show lemon collapse. Generally, grapefruit should not be recommended for use as a rootstock (7,40).

Troyer citrange (*Poncirus trifoliata* Raf. x *C. sinesis* Osbeck)

Troyer citrange is a hybrid of trifoliate orange with sweet orange, and has inherited some of the good qualities of each. It is resistant to gummosis and tristeza but susceptible to exocortis. Trees budded on it are more cold-hardy than those of sweet or sour orange but not so hardy as those on trifoliate orange (7,10).

This stock produces vigorous trees. Trees budded on it produce good yields and large fruit of excellent quality, better than those on sour orange (7,53). However, this stock is still in the experimental stage and has not been tested in many parts of the world because of the limited seed supply (7,71).

So far, Troyer citrange has shown marked promise with oranges, grapefruits and lemons with the exception of Eurekas which develop on it a severe bud-union disorder (50,70).

Rusk Citrange (*Poncirus trifoliata* Raf. x *C. sinensis* Osbeck)

Rusk citrange is another hybrid of trifoliate orange with sweet orange which is still under trials. Its tolerance to xyloporosis, tristeza, exocortis and gummosis is not yet established. So far, trees budded on it produce good yields and fruits of excellent quality (20,40).

Sweet Lime (*Citrus limetta* Tanaka)

Sweet lime is especially adapted to the light, sandy soils. It is resistant to tristeza, but susceptible to gummosis and xyloporosis. It is also sensitive to frost (10,58). It is used in some of the Mediterranean countries as a stock for the Shamouti orange. Generally, it has a dwarfing effect and trees on it are short-lived (7,71).

Rangpur Lime

Rangpur lime is not a true lime. It is believed to be a hybrid between the true lime (*C. aurantifolia* Swingle) and the mandarin orange (*C. reticulata* Blanco) (10).

This stock is adapted to sandy soils and has a considerable tolerance for saline conditions. It is resistant to tristeza and xyloporosis but susceptible to exocortis - Rangpur lime disease (24,58).

Chapter III

CITRUS PROPAGATION

It was early mentioned that budding on seedling rootstocks is the general practice in propagating citrus. Seedlings are grown from seeds in a seedbed. Some citrus growers prefer to plant seedlings in an orchard and have them budded there to the desired variety. This practice has the advantage of not moving the trees after they are budded. Planting and budding seedlings in the nursery is a much more common and better practice because it allows for better and easier care of the seedlings, in addition to the fact that the loss of a tree in the nursery is less serious than in the orchard (28).

The Seedbed

The seedbed is a specially prepared place where seedlings are grown from seeds. The size and kind of a seedbed depend upon the number of seedlings desired, available facilities, and whether it is for local or commercial use. Following are the important factors to consider and the procedures to follow in growing seedlings from seeds.

Selection of soil and site.

The seedbed should be established in a well-drained, sandy loam soil, and in a convenient place where it can be easily maintained and inspected (10).

To avoid soil-borne diseases and nematodes that affect citrus, it is recommended to use virgin soils if possible or else cultivated soils that have not been planted with citrus and have not been recently fertilized with organic matter. If old citrus soil is to be used, it is necessary to fumigate the soil thoroughly before planting (28).

Preparation of seedbed.

After the soil is plowed and cleared from gravel, stones and weeds, it should be made smooth and level to prevent erosion and quick runoff of irrigation water. The surface should be harrowed or raked into a fine state of tilth (28,71).

For a small number of seedlings, wooden boxes or frames of 12-inch boards may be used and filled with suitable soil. For a large number of seedlings and where shade is necessary, a lathhouse is desirable. A common way for constructing a lathhouse is to erect 4 x 4 - inch posts, 8 feet high and cover their sides and top with lath leaving spaces between to provide half shade (10,28).

Selection of seeds.

Seeds of the desired rootstock should be obtained from old vigorous trees that have remained free from disease and are known to produce vigorous uniform seedlings (10,28).

Seeds of Cleopatra tangerine, sour orange, trifoliate orange, Troyer citrange and rough lemon are used to produce seedling rootstocks for oranges; Cleopatra tangerine and sour orange for grape-

fruit; Cleopatra tangerine, sour orange and sweet orange for lemons; Cleopatra tangerine and trifoliate orange for mandarins(10,40,71).

Extraction of seeds.

Citrus seeds are very much affected by drying and once they have become thoroughly dry they are no longer able to germinate. The shorter the period between extraction of seeds and their planting, the higher is the germination rate. Therefore, it is recommended to leave seeds in fruits until planting time (18).

Seeds are extracted by cutting around the center of the fruit through the skin without injuring the seeds. Then fruits are twisted and separated into halves and squeezed onto a sieve where they are washed free from the pulp. The average number of seeds per fruit is about 10 to 15 in Troyer citrange, 15 to 20 in sweet orange and rough lemon, 25 to 40 in trifoliate orange, and 40 to 50 in grapefruit (28).

Storage and treatment of seeds.

If it is desired to store the seeds after extraction, they should be placed on a cloth or screen in thin layers in a shady place until their surface is dry, then they are mixed with clean sand and stored in boxes in a cool place (71). Seeds can be stored in sand at 42° F. for at least 5 months without marked reduction in viability (18).

In Florida, treating seeds with 1% solution of 8-hydroxyquinoline sulphate gave effective protection against fungus organisms and

29 out of 34 varieties showed 90% germination after 6 months storage in moist saw dust at 35° F. (10). The surface-dry seeds may be stored in a plastic bag in a refrigerator at 35 to 40° F. (71).

Seeds can be stored without drying if they are treated with a good fungicide, such as 8-hydroxyquinoline and mercury bichloride. This will protect seeds from mold and in some cases seedling chlorosis (28).

Citrus seeds often carry one or more of the brown rot fungi (Phytophthora) on the seed coat. Infected seeds may not germinate but by planting a single infected seed it is possible to contaminate a whole bed. Soaking the seeds in hot water at 120° F. for 4 minutes will destroy Phytophthora citrophthora and Phytophthora parasitica which cause brown or root rot gummosis (10,34.). If the seeds are to be planted at once, fungicides may be applied after the hot water treatment (28).

Planting the seeds.

Seeds of trifoliate orange, which is vary hardy to cold, are usually planted in the fall, but seeds of other citrus rootstocks are usually planted in spring as soon as danger of frost is past (71).

Seeds may be planted broadcast, but better seedlings develop from spaced plantings in rows. Shallow furrows 1½ to 3 inches apart are made by pressing a board into the soil to a depth of 3/4 to 1 inch. Then seeds are placed 1 inch apart in the furrows and are covered, preferably with clean sand (28). The soil should be kept moist, but not wet, until the seedlings appear in about a month, then water is applied as needed to keep seedlings from

wilting (10,71).

Care for the seedbed.

Proper irrigation is important for the successful growth of the seedlings. Irrigation may be needed every one to three days until emergence of seedlings, then every week after they are established. Overhead sprinklers provide the most effective method for irrigation of the seedbed. For small seedbeds, portable lawn sprinklers may be used (38).

Fertilizers should not be applied unless necessary. Citrus seedlings are less subject to disease when they are grown without fertilizers. Organic fertilizers should not be used because they encourage fungus diseases. If fertilization is necessary, as in the case of poor soil, nitrogen chemical fertilizers are used. Ammonium sulfate is preferred because it is not readily leached from the soil and it leaves an acid residue which helps control Pythium fungi that cause damping-off disease (28,71). Spraying is rarely needed in the seedbed, but care should be taken to control pests and weeds that may be found in the seedbed. All the weak, off-type or diseased seedlings should be eliminated. By the end of the growing season seedlings may be transplanted into the nursery (10,71).

The Nursery

Seedlings should not be kept for a long time in the seedbed, where they are narrowly spaced but should be transplanted

into the nursery where they are allowed more space for further growth and future budding.

Selection of soil.

The nursery should be established on a medium-textured, non-saline soil. Heavy clay soil is hard to work and makes balling difficult. Light, sandy soil requires frequent irrigation and fertilization. Virgin soil is preferable whenever possible, or soil that has not been previously used for citrus (28,71).

Selection of site.

The nursery should be located in frost-free locations, where the soil is satisfactory and water is available, with suitable access roads to facilitate cultural operations and removal of trees when they are dug (28).

If the same site is to be used for a nursery again, there should be a year or two between such uses in which green manure crops are grown and turned under (71).

Preparation of nursery.

The nursery soil should be well plowed, harrowed, leveled, and cleaned from stones and weeds. On recently leveled soils, application of one or two irrigations before planting helps settle the soil and facilitate releveling if necessary. A supply of good quality irrigation water should be available all the time (28).

Nursery rows are spaced 3 to 4 feet apart for mechanical cultivation. Furrows should be at least one foot deep. Row

length depends on the soil type and method of irrigation. For medium-textured soils rows 150 to 200 feet long are about right (71).

Planting the seedlings.

When the seedlings are at least the thickness of a lead pencil by the end of the growing season, they may be planted in the nursery (71).

Citrus seedlings are usually transplanted in spring after the danger of frost is past when they are about one year old. Seedlings that are cold-hardy such as those of trifoliate orange may be planted late in the fall (10).

Before transplanting the seedlings, the seedbed should be well-irrigated so that the seedlings will be turgid and easy to pull out. The seedlings should have their roots cut at a depth of 10 to 12 inches. Only vigorous seedlings of about the same size should be transplanted, discarding all weak seedlings and those with crooked roots (71).

The nursery soil should be worked to good tilth. Furrows should be deep enough to allow the shorted tap root to be in vertical position. Seedlings should be set in the nursery at the same depth they grew in the seedbed since the root system is adapted to that depth. Thorough irrigation is necessary immediately following planting to settle the soil around the roots and keep the seedlings from wilting (28,71).

Cultural operations.

Irrigation, cultivation, and fertilization should be continued. Spraying for the control of mites, aphids, thrips, and scale insects may be needed (27,71).

Proper and adequate irrigation is necessary. Over-irrigated trees turn yellow and grow slowly. Lack of water stunts growth and causes many buds to die before they unite with the stock. Furrow irrigation or sprinklers may be used (28).

Cultivation is primarily for weed control. Weeds should not be allowed to grow near the seedlings because they compete with them and retard their growth. Tillage or herbicidal sprays such as 2,4 dichlorophenoxy acetic acid may be used for weed control (28,71).

Fertilization is usually needed to maintain vigorous growth. An ammonium fertilizer is applied along the seedling rows at the rate of one pound of fertilizer for every 100 feet of row. The soil should be irrigated after applying the fertilizer (28).

The Budding Operation

The choice of a suitable stock and the selection of satisfactory budwood are the two most important factors for successful budding. Under the Budwood Registration and Certification Program it is now possible to obtain budwood which is certified free from bud-transmitted viruses and true to type for the variety (46,52,71).

Time for budding.

Citrus seedlings may be budded in the fall at the end of

the growing season, or in the following spring, a year from the time they were planted in the nursery (28). The stem of the seedling to be budded should be at least 1/4 to 3/8 inch in diameter (10).

Budding can be done only when the bark can be easily separated from the wood. Most budding of citrus is done in the fall -- October and/or in spring. Budding in the fall is called dormant budding because the bud stays dormant all winter if budding is not done too early. If budding is done late in summer, or too early in the fall, the bud may start growth and be subject to cold injury. If budding is too late in the fall, the stock may be dormant and the bark will not slip and buds will fail to unite with the stock. The dormant buds unite with the stock in the fall and can start growth early in the spring, at least one month before the spring buds. Spring buds need about a month to unite with the stock and start growth (28,71).

Selection of budwood.

Budwood should be selected from vigorous, true to type, heavy producing, disease-free trees. Extreme care should be taken to select budwood only from certified trees that are free from virus diseases (26,52).

The budstick should be all of one flush of growth, usually the next from the tip of the twig, having 5 to 10 buds not yet starting into growth. Round, well-matured wood about 3/16 inch in diameter yield more usable buds. Immature angular wood should be discarded (10,28).

Cutting and storing budwood.

Budwood should be preferably cut just prior to use and the leaves should be cut at once. Budsticks must not be allowed to dry and may be kept in damp cloths or peatmoss. In spring the buds may start into growth as soon as the bark will slip. Therefore, it is better to assure enough supply of unsprouted buds by cutting budwood before buds begin growth (71).

Budsticks should be grouped in bundles, labeled, and stored in a good storage medium such as damp peat moss or sawdust in boxes or folded burlap and kept in a cool dark place (28).

Budding procedures.

"T" or "shield" budding is the most common method for budding citrus seedlings. It is easy to do and has given excellent results. The "T" refers to the cuts made in the bark of the seedling and "shield" to the scion piece which is cut in a shield shape (71).

A bud is sliced from a budstick with a shield-shaped piece of park about 3/4 to 1 inch long. The cut should be made deep enough in the budstick to include a sliver of wood with the bud. A perpendicular cut is made through the bark of the seedling stem and another horizontal cut is made at the upper end of the perpendicular cut. Then, the bud is inserted in the opening at the junction of the cuts with the right end up (Fig. 1). Finally, the bud is wrapped with rubber bands, raffia, or plastic strips (28).

In some citrus growing areas the cuts are made to form an inverted T, so that the shield is pushed up from below. Both

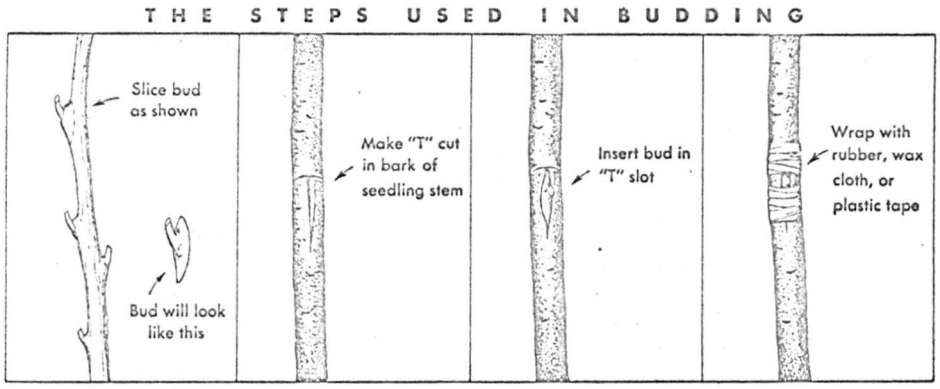

Fig. 1 -- Steps used in "T" or "shield" budding.
(From Johnston, J. C., et al. 1959. (28).)

methods give excellent results without superiority of either method over the other (71).

The buds should be set 6 to 8 inches above the ground, especially in wet areas and when the budded variety is susceptible to gummosis (5,10).

Unwraping and forcing the buds.

About 3 weeks after budding, the wrap may be removed and the bud examined. If it is still green and callus tissue has formed, the bud is alive and has "taken." If the shield has turned brown and slips easily out of the incision, a new bud may be inserted at another place if the bark will still slip, or rebudding may be done in spring. (71).

When the bud is ready to grow, the seedling top is usually cut off just above to force it into growth (10). Some nurserymen prefer to leave some leaf surface above the bud to supply food for the roots. This is usually done by cutting of the seedling top, 3 to 6 inches above the bud or by partly cutting and lopping the top above the ground. When the bud shoot is about 1 foot tall, all remaining parts of the seedling top should be cut back to the base of the shoot (10,28).

The bud shoot and the stock constitute a "budling" or a young budded tree (71).

Staking and training.

Citrus budlings should be provided with support to keep them upright. A wooden stake, 4 feet long and 1 inch square should be

placed an inch away from the budling shoot and be driven 6 to 8 inches into the ground. When the budling shoot is 5 to 6 inches long, it should be tied to the stake with soft twine or raffia. Additional ties should be made at about 10 to 15 inches as the shoot continues to grow. By the end of the growing season the stakes may be removed (10,71).

The shoot may be cut back at about 2 to 3 feet and 3 to 5 well-spaced shoots are selected to form the main branches in the future, removing all other shoots (28).

Digging the Budlings

At the end of one growing season after budding, the budling should be ready for planting in the orchard. The first step in digging is to cut off the top of the budling at a height of about 2 feet. Branches may be cut back to 6 to 8 inches (71).

Balled trees.

Most citrus budlings are dug with a ball of soil around the roots (Fig. 2). This gives more time between digging and planting. Balled trees start growth earlier after being transplanted to the orchard than bare-rooted trees (10,28).

For balling, a special spade 16 inches long is used. Thrusting the spade straight down 4 inches from the trunk on all four sides will cut all lateral roots and makes a ball about 8 inches in diameter. After the last thrust, the spade is left in position and soil is removed from the other side. The tap root should be

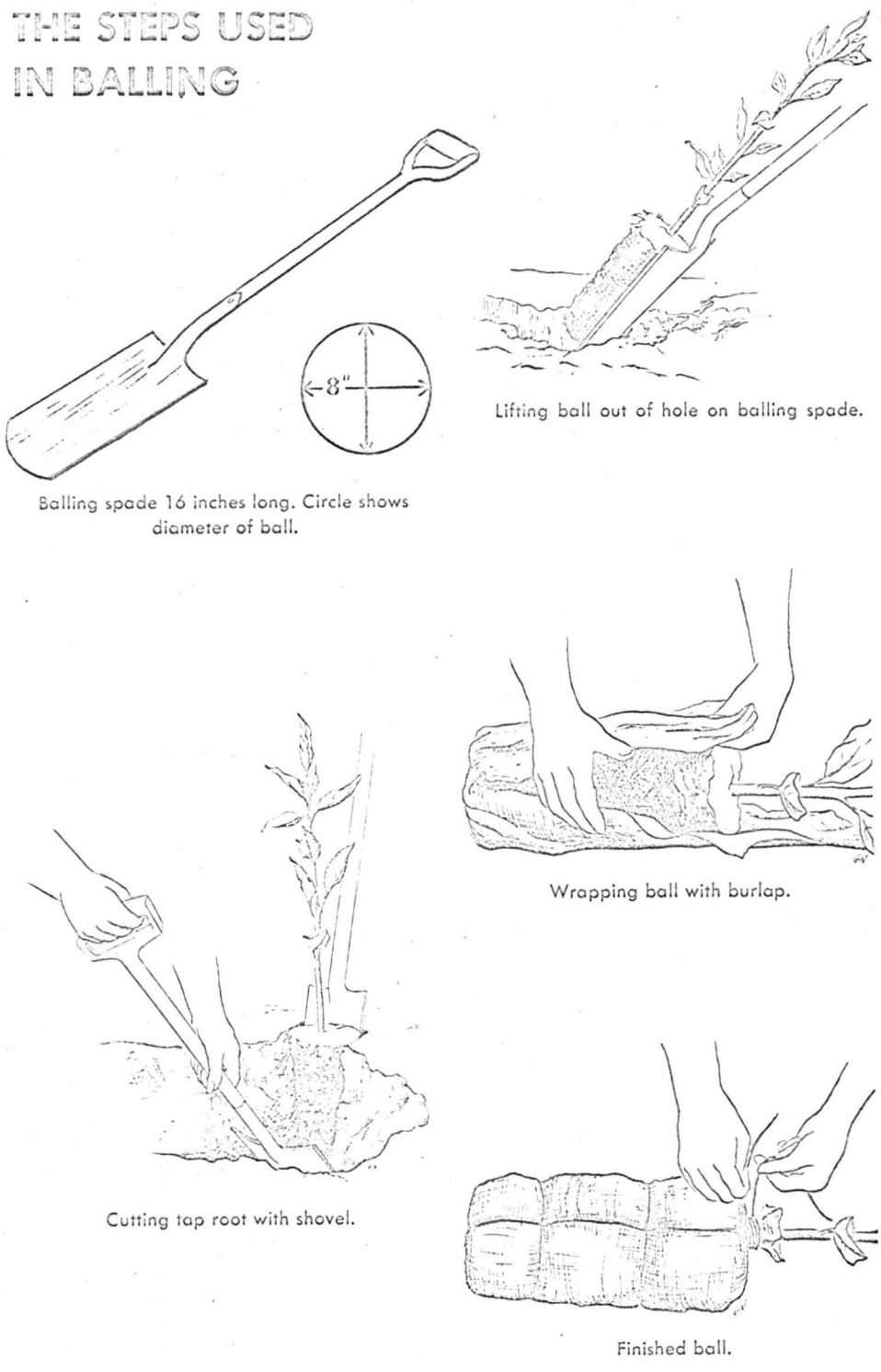

Fig. 2 -- Steps used in balling nursery trees for transplanting. (From Johnston, J. C., et al. 1959. (28).)

cut at a depth of 12 to 16 inches with another spade or shovel. Then the tree is lifted up and the ball is placed on a piece of burlap and wraped tightly (28,71).

Bare-rooted trees.

Bare-rooted trees should be handled quickly and carefully to keep the roots from drying. On heavy soils bare-rooting is easier and preferred to balling. Bare-rooting allows for inspection of the root system and more roots are left than on balled trees (28,47).

Chapter IV

SUMMARY

Budding on seedling rootstocks is the general practice in propagating citrus. Rootstocks influence vigor, longevity, cold hardiness, yield, fruit quality, and disease tolerance or resistance. No citrus rootstock is superior on all of these qualities. The choice of a stock, therefore, must be made for a particular stock-scion combination in a particular environmental condition. The most important factors to consider in citrus rootstock selection are presented in Table I.

Seedlings are grown from seeds in a seedbed. Citrus seeds are very much affected by drying and once they have become thoroughly dry they are no longer able to germinate. The shorter the period between extraction of seeds and their planting, the higher is the germination rate. Seeds can be stored in sand or moist sawdust at 35 to 40° F. for a period of 5 months without marked reduction in viability.

By the end of the growing season in the seedbed, seedlings may be transplanted into the nursery. Nursery seedlings may be budded in the fall at the end of the growing season or in the following spring, a year from the time they were planted in the nursery. Most budding of citrus is done in the fall and/or in spring. Budding in the fall is called "dormant budding" because the bud stays dormant all winter. The dormant buds unite with the

TABLE I

Summary of the most important factors to consider in citrus rootstock selection.

Rootstock	Disease Resistance (R) or Susceptibility (S)	Production	Fruit Quality	Longevity	Relative Hardiness	Best Results With	Preferable Soil Type
Rough Lemon	R-tristeza R-xyloporosis S-gummosis S-Lemon shell bark	good 1st 15-20 yrs.	very poor	short-lived	tender	navel oranges	sandy
Sour Orange	R-gummosis, R-xyloporosis S-tristeza S-Lemon shell bark	good	good	average	hardy	oranges grapefruit Lisbon lemon	sandy loam to clay loam
Cleopatra Tangerine	R-tristeza R-gummosis R-xyloporosis	good in late yrs.	good	average	hardy	oranges grapefruit lemons mandarins	sandy loam to clay loam
Sweet Orange	R-tristeza R-exocortis R-xyloporosis S-gummosis	good	good	long-lived	hardy	oranges lemons grapefruit	sandy loam
Trifoliate Orange	R-tristeza R-gummosis R-xyloporosis S-exocortis	good	excellent	average	very hardy	oranges mandarins	sandy loam
Grapefruit	R-gummosis S-tristeza S-lemon collapse	low	good	average	hardy	lemons	sandy loam to clay loam
Troyer Citrange	R-tristeza R-gummosis S-exocortis	good	excellent	average	very hardy	oranges	sandy loam to clay loam

stock in the fall and start growth early in the spring, at least one month before the spring buds.

Budwood should be selected from vigorous, true to type, heavy producing and disease-free trees. Round, well-matured budwood yield more usable buds. Immature angular wood should be discarded. Budsticks may be stored in damp peat moss or sawdust and kept in a cool dark place.

"T" or "shield" budding is the most common method for budding citrus seedlings (Fig. 1). The buds should be set 6 to 8 inches above the ground, especially in wet areas and when the budded variety is susceptible to gummosis. When the bud is ready to grow the seedling top is cut off just above the bud to force it into growth. The budling shoot should be provided with support to keep it upright.

At the end of one growing season after budding, the budling should be ready for transplanting in the orchard. Most citrus budlings are dug with a ball of soil around the roots (Fig. 2).

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