THE PROPAGATION OF CITRUS IN THE KERAVAT—RABAUL AREA

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INTRODUCTION.

INVESTIGATIONS on citrus culture were initiated at the Lowlands Agricultural Experiment Station, Keravat, prior to 1939, but most of the material was destroyed and the records were lost during the war. It was then necessary to make an entirely new start with this work in 1949.

The main objectives have been to test the suitability of various stocks under local conditions; to study stock-scion relationships; to determine the varieties which may be grown successfully in the Territory; to establish satisfactory nursery techniques and to study methods of control of pests and diseases.

THE CHOICE OF THE STOCK.

Rough lemon (*Citrus limona*), Trifoliata (*Poncirus trifoliata*), Seville Orange (*Citrus aurantium*), and the local "muli" or lime (*Citrus acida*) were tested. Other stocks, especially those of local origin, may also prove to be worthy of trial.

(*a*) *Rough Lemon.*—

Rough lemon has been a standard rootstock in commercial citrus plantings. It is vigorous, tolerant to a wide range of soil conditions, compatable with most citrus varieties and has a favourable influence upon the quality of the fruit produced by the scion budded on to it. The main disadvantage of rough lemon is its susceptibility to root rots, especially on soils which remain wet for long periods. No trouble with root rots has been experienced in the Keravat area, probably because of the porosity and excellent drainage of the local soils.

The Keravat seed stocks of rough lemon were obtained from the Kamerunga Experiment Station, Cairns, North Queensland. Germination in 1950 was excellent, and growth so vigorous that budding could begin only ten months after sowing. There was an excellent "take" and the growth of the scions was rapid. A further advantage of this stock was the readiness with which the bark would lift at almost any time; there was no marked period of dormancy. Thus, budding could be performed wherever budwood was available.

(*b*) *Trifoliata.*—

The Trifoliata stock has proved very valuable in Australia, owing to its high resistance to root rots caused by *Phytophthora* spp. and similar organisms, which affect citrus, especially when planted in damp areas. However, it has not proved to be a good stock for most lemon varieties. Results with this stock at Keravat have been most disappointing. It does not seem to be adapted to local conditions, and grows very slowly. It has also been noted that trees imported from Australia budded on to this stock, have made poor growth in various parts of the District.

(*c*) *Seville Orange.*—

This rootstock is known to be resistant to root and crown diseases, but has been little used in Australia except as a stock for lemons. It is considered superior to other stocks in many overseas countries, and scions budded on to it are said to produce fruit of particularly good quality. Germination and growth of Seville Orange at Keravat have been very good, and this stock appears promising.

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(*d*) *Lime* (*Local "muli"*).—

This species was selected because of its local adaptation. It excels in vigour and freedom from disease and also seeds very freely, which is an advantage for propagation. The seedlings of this stock at Keravat were very vigorous, and the "take" of buds was excellent. It appears already to have distinct possibilities, but further information is needed on its compatibility with different scions.

THE CHOICE OF THE SCION.

(*a*) *Variety.*—

In the past, Citrus varieties have been imported from Australia more or less indiscriminately, but the majority have been reasonably successful. Some, with sparse foliage, have suffered from sunscald, and a few have not grown satisfactorily. In some instances, the poor growth may have been caused primarily by the root-stock. Trials are necessary to determine the varieties best suited to local soil types, and it is hoped at a later date to classify many clones on the basis of local adaptation. Local as well as introduced varieties will be considered.

(*b*) *Selection of the Scion Material.*—

The benefit of a vigorous stock is largely lost if the scion is not chosen with equal care. Where possible, "certified budwood", which can be obtained from the State Departments of Agriculture in either New South Wales or Queensland, should be used. This budwood is certified to come from high-yielding trees which are true to type. If it is necessary or desired to utilize local material, budwood should be selected from vigorous, healthy trees with a known cropping history, as far as possible. To bud from unknown trees which are not in bearing is often misleading, as trees which have not had their vigour depleted by heavy cropping are frequently the most attractive. Moreover, bud variation occurs in citrus from time to time, and not all trees may be true to type. Selected budwood should be as free as possible from angulation.

NURSERY PRACTICE.

(*a*) *Growing Stocks from Seed.*—

Seed should be selected as far as possible from vigorous, disease-free trees, but fruit characteristics are of little importance in the selection of stocks. The seed should be removed from the fruit, covered with water and washed daily for three days to remove the mucilage. Alternatively, the seed may be allowed to stand in the fermenting juice for two days and then washed thoroughly prior to planting. Misshapen and floating seeds should be rejected.

Sowing should take place as soon as possible after deseeding. If delay is unavoidable or if the seed must be shipped some distance, it will keep better if packed in finely ground charcoal which has been moistened slightly. This prevents excessive drying out, which reduces germination.

Seed-beds are best made in well-drained virgin soil which has been well tilled. About 20 feet to 25 feet long by 4 feet wide is a useful size. The seed is planted in drills about six inches apart, with two inches between seeds. If the site is exposed, it is advisable to build a low shelter with bamboo slats over the beds. This shelter reduces the light intensity and conserves moisture. Overshading should be avoided, as it may lead to "damping off", a fungal disease which causes heavy losses in young seedlings and is difficult to eradicate from the seed bed.

(*b*) *Transplanting Seedlings to Nursery Rows.*—

Well-grown seedlings will be large enough to transplant at about three months. When they are removed from the seed-beds, they are carefully culled and any plants with poor root systems are discarded, as well as twisted, deformed or dwarfed plants. About twenty per cent. of the seedlings will probably be eliminated thus.

Nursery row lines should be so spaced as to permit convenience of working, especially during the operation of budding. Double rows two feet apart, with fifteen inches between plants, are satisfactory. A lane three feet wide should be left between each double row; the operator can then move easily along the three feet lane, budding the material on either side.

BUDDING.

(a) The Budding Operation.—

Budding does not require very much skill, but care is necessary for good results, and some operators never become first-class budders. The main essentials are care and speed in handling the bud and the stock so that the cambium, the actively-growing tissue just beneath the bark, is neither damaged in any way nor exposed too long to the air. Better results may be expected if some shade is provided during budding operations.

The best size for the stock is about three-eighths of an inch in diameter. Selected stocks are stripped of leaves, thorns and shoots for about ten inches from ground level, preferably with a sharp pair of secateurs. Pruning debris should be removed and burnt, as a precaution against disease.

The ordinary " T " bud is most used on citrus, and is quite satisfactory. An inverted "T" is preferred as moisture is then less likely to enter. The only tools required are secateurs, tying material and a sharp budding knife. Raffia is preferred for tying, but rubber tape, waxed tape or even narrow strips of wild banana leaf may be used. A special budding knife is best, and expedites the process if much budding is to be done, but any sharp knife will do.

The bud stick (scion) is taken and the leaves trimmed off, leaving the petioles or leaf stalks attached. The petiole facilitates handling and prevents damage to the bud. A cut similar to an inverted "T" is then made through the bark of the stock, choosing a smooth area of bark for the incision. The vertical cut should be about one and a-half inches long and the horizontal cut about three-eighths to half an inch. The bark is loosened at the junction of the two cuts by a little pressure sideways on the cut edges of the bark, but it must not be prised up, for this would damage the cambium. With a little practice, it is easy to loosen the bark with a slight twisting movement when completing the cut.

The bud or shield is now cut from the bud stick with a single clean cut of the knife. The cut stars about half an inch above the bud and finishes about half an inch below it, and is made about a sixteenth of an inch into the wood beneath the bud. The bud is thus held in an oval or shield-shaped piece of bark, about one to one and a-half inches long and a quarter of an inch wide. The small piece of wood is generally removed by holding the shield between the thumb and finger (handle it by the petiole, not the cut edges), and flicking the piece of wood out with the point of the knife. It must not be prised out and the cambium must not be touched with either the fingers or the knife.

The bud is then pushed in under the "T" cut with gentle pressure. Care should be taken that it is inserted the right way up and that none of the shield is showing below the cross cut of the " T ". Tying, which should be firm but not so tight as to damage the stock, should completely cover the whole of the " T " cut and extend a little beyond it in order to prevent the entry of moisture. The small bud itself should be left uncovered.

The " T " cut is best made about six inches above ground-level so that heavy rains will not cover the bud with mud.

Experiments with a commercial budding paste containing a hormone ingredient have indicated that the effect is to increase callous formation but at the same time

the bud is slower to break into growth. Its use could only be recommended with valuable material where maximum "take" was of the greatest importance.

Budding may be undertaken at almost any time of the year, provided the bark will lift easily. The period just prior to a leaf flush is probably best. April and May are, perhaps, the best months in the Rabaul-Keravat areas, as there is then less danger of damage to the buds from excess moisture.

With experienced operators, the fastest work is often done if one goes ahead and inserts the buds and the other comes behind and ties. The stocks should, of course, be prepared for budding in advance.

(*b*) *After Care of the Buds.*—

The tying material should be cut two to three weeks after budding. It is severed by a vertical cut on the side opposite the bud, thus removing any pressure on the plant, and left to fall off later. It will be obvious when buds have not taken, and such stocks should be rebudded immediately on the opposite side.

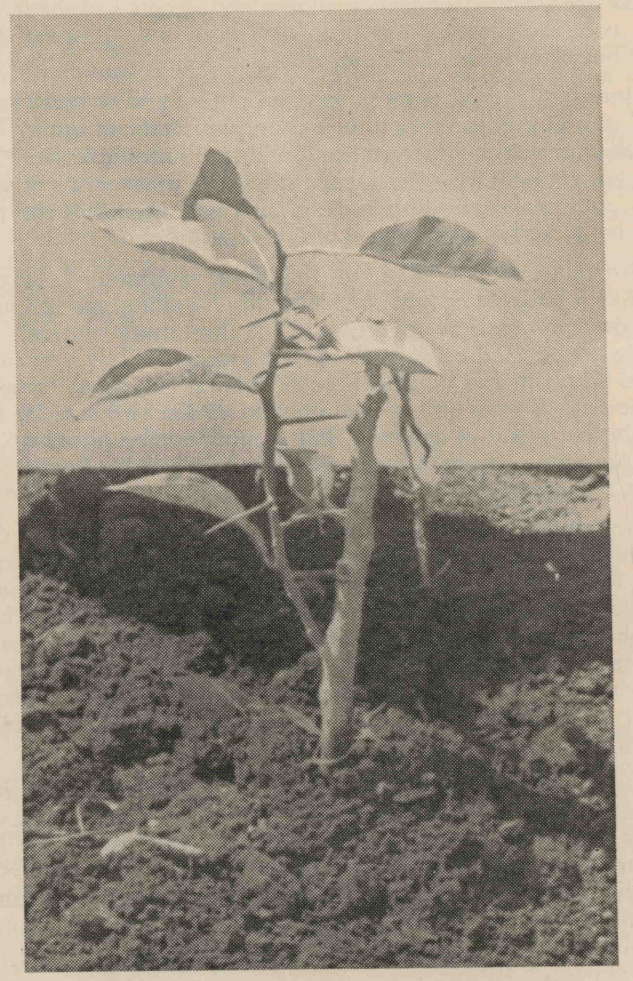

FIG. 1A.—YUZU BUDDED ON TO LIME STOCK, ILLUSTRATING TYING METHOD ADOPTED FOLLOWING TOPPING OF THE STOCK.

If the bud is healthy, the stock is stumped back to six to nine inches above the point of insertion. The bud should then develop quickly and the shoot may be tied to the stock to prevent it being broken or blown out (see Figure 1A). All shoots from the stock are carefully removed close to the main stem. As the shoot develops it is usually necessary to stake it (Figure 1B), and when it is two feet to three feet high, the stock should be cut back close to the point of union with a sloping cut on the opposite side, and sloping away from the union, leaving no stub at all.

FIG. 1B.—CITREMON BUDDED ON TO LIME STOCK, ILLUSTRATING METHOD ADOPTED IN TRAINING THE BUD SHOOT ALONG SAWN TIMBER STAKES.

(c) *The Formation of the Tree.*—

As the shoot develops, all side shoots should be removed. When it is about three feet tall, it is cut back to about 20 inches and should then support itself without a stake. Only the top three or four buds are permitted to develop, all lower shoots being pruned off close to the trunk. These three or four upper shoots form the basic branch structure of the tree. A well-formed tree is shown in Figure 2A. Notice how the bud union is callousing over.

FIG. 2A.—LISBON LEMON, SHOWING DESIRED SCAFFOLD STRUCTURE AND CALLOUSING OVER OF THE BUD UNION.

TRANSPLANTING THE TREE TO A PERMANENT SITE.

As the tree develops, it must be removed from the nursery to a permanent site. The ideal size is indicated in Figure 2B. The three or four scaffold branches are cut back to about a foot from the main trunk, and all thorns and leaves carefully removed from the tree. A circle is then dug around the tree with a spade, at a distance of about eight inches from the main stem, severing all lateral roots which spread beyond that distance. The tree is then eased gradually from its position in the nursery row. Especially when it is to be transported any distance, excessive earth may be removed by shaking or washing, and the tap-root shortened with the secateurs. Malformed roots may also be removed, within reason.

When transport over any distance is necessary, the roots are "puddled" by being dipped into a sticky mixture of clay and water, and then packed in moist sphagnum moss, damp sawdust or similar material, and bound with sacking. With careful packing and some arrangement for periodical watering, trees will survive long journeys without detriment.

FIG. 2B.—VILLA FRANCA LEMON AT A STAGE IDEAL FOR TRANSPLANTING FROM THE NURSERY.

DISEASES AND PESTS OF CITRUS.

(*a*) *Diseases.*—

Die-back (Diplodia)

Die-back frequently causes severe economic losses, especially when rough lemon stock is used.

The disease gains entrance mainly through pruning cuts, especially when stems above about three-eighths of an inch in diameter are pruned. Losses are particularly heavy when the stock is stumped in order to promote bud growth. The bark dies and turns brown, and the heartwood is also killed and often streaked with black or red streaks. As infection progresses down the stem, the bud is often killed, even if it has begun to shoot.

Control is obtained by preventing the entry of the causal fungus. The following procedure might be adopted:—

(1) Spray the stocks at least two days prior to budding with Bordeaux mixture.

(2) After budding, spray the stock regularly with a Bordeaux-white oil-D.D.T. mixture, until the bud shoots.

(3) When the stock is cut back, dress the wound with an antiseptic such as four per cent. formalin or one in one thousand corrosive sublimate. Two or three days later, a further dressing of thick oil paint or wax should be applied.

(4) Sunscald may be a factor contributing to infection. Painting of the butt with limewash will minimize this trouble, but if the giant snail (*Achatina fullica*) is present, Bordeaux paint will give dual protection.

(5) Continue to spray the developing bud with the Bordeaux-white oil-D.D.T. spray at about monthly intervals, the frequency depending on local rainfall.

FIG. 3A.—LEAVES OF A LEMON TREE WITH SYMPTOMS OF CITRUS CANKER. NOTE THE SPOTTING WHICH GIVES RISE TO THE TYPICAL "HALO EFFECT".

(6) Where infection has taken place, cut well below the lesions into healthy wood and apply antiseptic measures to the wound, as detailed above.

Any soil deficiency or other factor contributing to poor tree health will increase the danger from die-back. Sawn timber, painted with sump oil as a preservative, should be used for staking the buds rather than bush material which may carry infection. All infected prunings should be burnt.

Citrus Canker (*Phytomonas citri*).

This is a bacterial disease of considerable economic importance. It may cause heavy leaf fall, and some dropping and blemishing of the fruit.

The symptoms are characteristic. Whitish or yellow circular markings appear on the leaf blade and the centres of the lesions become raised, giving rise to a typical canker surrounded by a halo of pale tissue. The canker is found also on the twigs and branches, but without the halo.

FIG. 3B.—A LEMON TREE WITH CITRUS CANKER ILLUSTRATING THE DEFOLIATION OF TERMINAL GROWTH.

Citrus canker may be controlled by spraying with Bordeaux at about monthly intervals. The incorporation of a little D.D.T. is advisable, as this will control the leaf miners and chewing insects which assist the spread of the disease. All infected twigs and branches should be pruned off and burned, and the cut surfaces treated with an antiseptic solution.

Every effort should be made to isolate infected trees and care should be taken to avoid introducing this disease into new plantings.

Pink Disease (Corticium salmonicolor).

Pink disease attacks twigs or branches causing girdling and death. The distinctive salmon pink colour serves to identify it. Pruning of affected limbs followed by antiseptic measures will give control. Spraying with lime-sulphur or Bordeaux is both preventative and curative.

Damping-off (Pythium spp.).

Damping-off may be the cause of poor germination, when seedlings are attacked before emergence, or may attack the young plants after emergence. The seedlings fall over and the tissues are black and shrunken at ground level.

Nursery hygiene and management give the most effective control. Damping-off is favoured by excessive shade and moisture. Seed-beds should thus be encouraged to dry out quickly after rain by adjustment of the covers, and should be fully exposed to sunlight and dried out between plantings. Removal of excessive weed-growth and affected seedlings will also help. The nursery site should be well drained.

Affected beds may be sterilized by heat or chemicals, but both methods are costly on a large scale. If Cheshunt mixture is sprinkled on the soil at intervals of three to five days, some control is obtained. Bordeaux spray can be used after the second pair of leaves is formed.

Other Diseases.

Other minor fungal diseases have been observed, but they can be controlled by spraying, pruning and general good management.

Minor element deficiencies do occur on pumice soils, but it is not always easy to identify the trouble. Zinc and magnesium deficiencies both cause leaf mottles and copper causes a typical condition characterized by bush growth and drooping glossy foliage. Spraying or soil applications of salts of the deficient element will usually remedy the trouble. It is hoped to discuss mineral deficiencies in detail at a later date.

Applications of mixed fertilizers containing nitrogen, phosphorus and potash, with or without minor elements, are usually beneficial, but costs may be prohibitive.

(*b*) *Insect Pests.*—

The following insect pests have been recorded on citrus at Keravat, in order of importance :—

Leaf Miners (*Phyllocnistis* sp.).
Black Scale (*Chysomphalus* sp.).
Red Scale (*Aonidiella aurantii*).
Leaf Curling Moth (Unidentified spp.).
Aphids (*Toxoptera aurantii*).
Beetles (*Glycyphaiya* sp. and *Rhyparida* sp.).

Most of these pests are controlled by D.D.T. preparations, but the scales require an oil spray. Nicotine sulphate is a good contact insecticide for aphids and the new product " Phosfone 20 " is also excellent.

A compound spray may generally be used, thus obviating the necessity for individual applications. To the Bordeaux may be added white oil, nicotine sulphate, and D.D.T. " Phosfone 20 " breaks down quickly in alkaline solution and should not be mixed with Bordeaux or basic white oil unless it is to be applied immediately.

The sprays and antiseptic solutions mentioned in this article are made up as follows:—

Bordeaux Mixture.—

Calcium oxide (quicklime)—4 parts.

Copper sulphate (bluestone)—4 parts.

Water—40 gallons.

Dissolve the copper sulphate in a small quantity of water in a wooden barrel or other *non-metal* container. Dissolve the lime also in a small quantity of water and mix, adding the remainder of the water. Test the solution by placing in it a nail or other small iron object, and if copper is deposited on the nail, continue to add lime until this ceases, when the solution will be approximately neutral.

Bordeaux Paint.—

Solution A.—

Copper Sulphate—1 lb.

Water—three-quarters of a gallon.

Solution B.—

Calcium Oxide—1½ lb.

Water—three-quarters of a gallon.

Mix solutions A and B, with frequent stirring, in a wooden, earthenware or copper container. Vessels made of iron must not be used. The result is a bluish paste about the consistency of paint. Water may be added to this paste to produce a spray, if required.

Cheshunt Mixture.—

Copper Sulphate—two ounces.

Ammonium Carbonate—eleven ounces.

The two compounds are ground together, and one ounce of the mixture is dissolved in a gallon of water when required. This quantity is sufficient to cover two square yards of seed-bed.

Formalin Solution.—

For dressing wounds, one part of commercial forty per cent. Formalin is added to nine parts of water. The addition of a little denatured alcohol (methylated spirits) will assist penetration.

Mercuric Chloride.—

Mercuric Chloride, one part dissolved in one thousand parts of water, is a good wound dressing. The substance should be dissolved in a small amount of hot water and cold water added to make up the volume. Mercuric chloride is highly poisonous, and should be handled and stored with care.

Other Fungicides.—

Commercial copper preparations such as Bordinette, Cuprox, etc., may be substituted for Bordeaux mixture and used as directed on the containers.