

THE PROPAGATION OF CITRUS

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UNIFORMITY is the keynote in modern citriculture. The successful grower has to grade his produce and market it with the stamp of distinction in order to catch the public eye for uniform high quality fruit. At the same time he has to bring about direct improvement in yield and quality by the provision of genetically uniform high grade planting material. With such uniform trees he will be in a position to assess the value of his cultural and manurial treatments in the orchard more accurately by experiment, since variability due to differences in genetic constitution is eliminated.

SEEDLING AND VEGETATIVE PROPAGATION

The planting of seedling trees in the orchard is at the moment out of the question because of their extreme variability in growth and yield. They take long to bear and in the end may produce fruits widely different from the parent type. It is known that some varieties of citrus are cross fertile. A good variety is likely to be fertilised by pollen from other citrus trees in the neighbourhood and the hybrid seedlings, if any, generally escape notice in the seed bed.

Besides, the present day market demand is for seedless varieties and this rules out seedling propagation altogether.

Of the methods of vegetative propagation the most popular one for citrus is budding—a scion bud of the desired variety being worked on a seedling rootstock.

While the large scale planting of a single scion variety will tend to give a certain degree of uniformity of fruit type, it does not eliminate the variable effect which seedling rootstocks of diverse genetical makeup have on scion performance.

These variations in growth and productivity of uniform scions when worked on variable stocks are of such great economic significance that they indicate the necessity for using only standardised planting material in the orchard.

Research especially at East Malling, England, on temperate fruit crops has revealed that the variations in tree size, time of bearing, yield and quality of fruit, which occur when seedling rootstocks are employed may be as great as if the trees were all entirely seedlings.

More recently Webber working on citrus at California has demonstrated the variable effect of ordinary citrus nursery stocks on growth and yield of orchard trees (1). These citrus nursery stocks as ordinarily grown were found to consist of a 'very large number of widely different types of different genetic constitution, exhibiting a wide range of characters.'

This difficulty may be got over within limits if the desired variety is established on its own roots by means of cuttings, layers or marcots, or if it is worked on clonal rootstocks, *i.e.*, rootstocks all of the same genetic type.

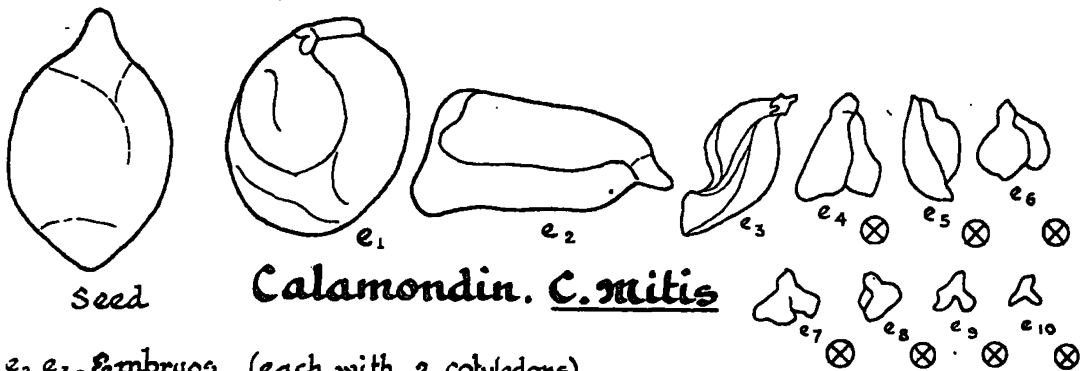
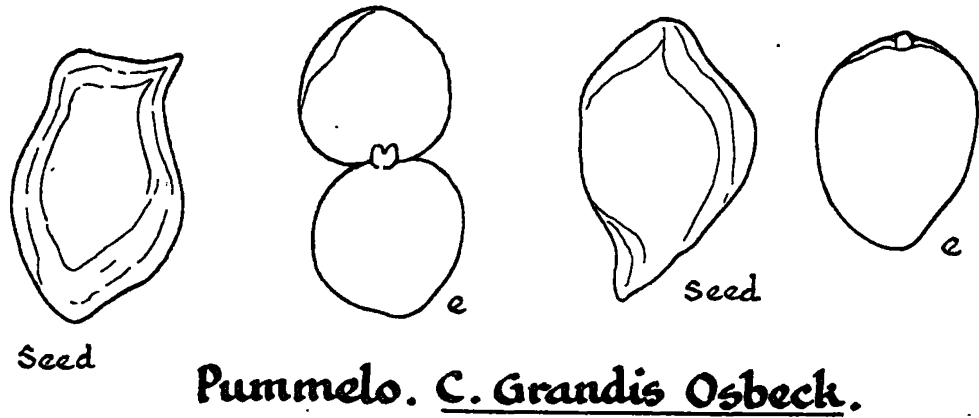
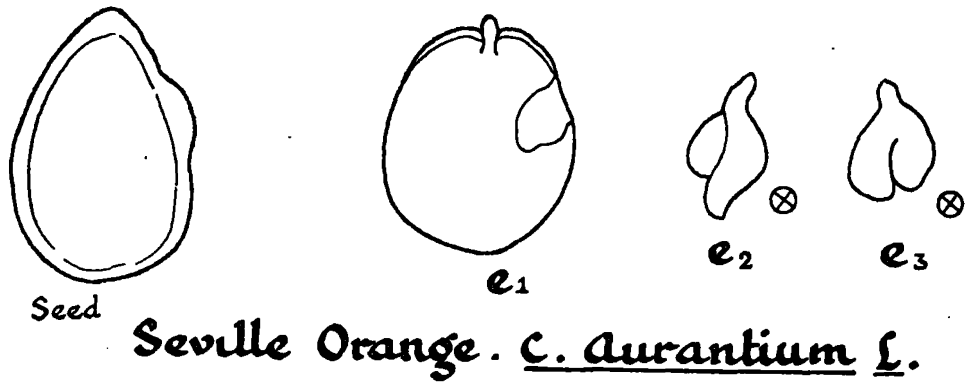
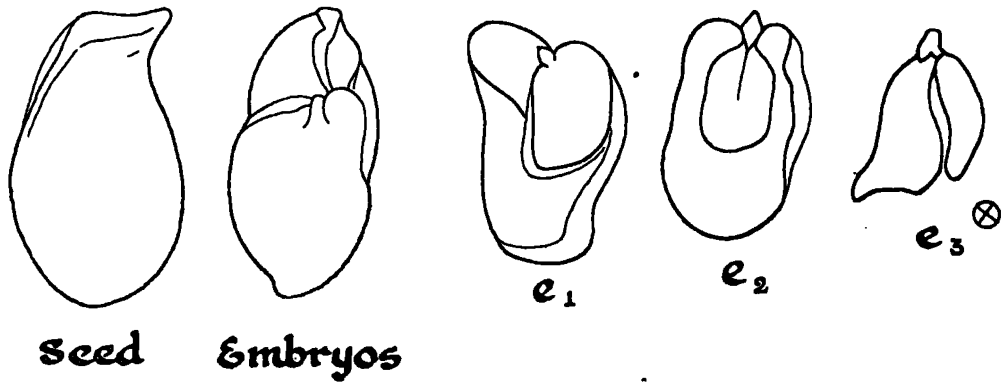
In England more interest is being taken in clonal rootstocks propagated vegetatively as stools, layers, root cuttings, hardwood stem cuttings, and softwood stem cuttings. Even suckers are used in commercial nursery practice.

At East Malling the vegetatively propagated "Paradise" apple rootstocks have been further classified as dwarfing or vigorous stocks according to their effect on growth and cropping of the scion variety worked on them. So that the English fruit grower is in a position to secure greater degree of uniformity in the orchard by controlling the behaviour of the scion through clonal rootstocks of known potentialities.

Whatever the influence of stock on scion may be, it will not be possible to exploit it for economic gain if the scion variety is established on its own roots.

A certain standard of uniformity may probably be reached by growing such 'own root' trees but their behaviour will be largely determined by varietal characteristics and local environment. Webber in his survey of citrus in South Africa where the sour orange had for some unknown reason failed as a stock

Citrus Embryos



e_1 e_2 e_3 - Embryos (each with 2 cotyledons)
 ⊗ - Embryos that failed to germinate.

for oranges observed that layered Washington Navel trees ten year old were doing just as well on their own roots as budded plants on rough lemon stock (2). Layering is generally a slow and cumbersome process, and yet Webber was so impressed with the performance of the 'own root' trees that he recommended a serious trial of vegetative propagation methods to raise not only 'own root' scions but also clonal rootstocks.

In the wet tropics, the high incidence of disease and the periodic occurrence of drought will necessitate the use of suitable resistant rootstocks for the improved scion varieties which are delicate subjects on their own roots.

For the hardier varieties, however, which by experiment are found to do just as well on their own root systems as on others, it may be convenient to dispense with rootstocks altogether if a rapid and cheap method of propagation from cuttings is available.

An interesting feature in the case of citrus and mango is the common occurrence of Polyembryony. A seed may contain in addition to the sexual embryo which is formed by normal sexual process, other embryos all arising as buds from the maternal tissue—the nucellus (3). This accounts for the appearance of more than one little seedling when a single seed is planted (See diagram).

The sexual embryo may survive in the competition and germinate, but it is very difficult to distinguish its seedling—the generative seedling—from the other vegetatively produced or apogamic seedlings unless it bears some leaf characteristics peculiar to its male parent. It will be almost a hopeless proposition to pick out and eliminate all the generative seedlings in a large nursery if a rootstock variety which produces both monoembryonic and polyembryonic seeds is self fertilised or is crossed by obscure male parents in the vicinity (4).

Theoretically the apogamic seedlings will be regarded as clones in that they all have the same genetic constitution as the mother plant. They will have none of the disadvantages popularly ascribed to vegetatively propagated material such as lack of tap root, liability to be uprooted by wind, one-sided rooting, etc., but they do show marked variability in initial

vigour due probably to differences in size of the embryos. The embryos which are crowded together generally vary in size, some being far too small to survive in the seed bed.

These variations in growth may be maintained for several years in a long-lived slow-growing perennial like citrus.

Rigorous selection will have to be practised in the nursery to eliminate not only the hybrids but also the small or stunted seedlings of the same progeny.

It seems from the above considerations that varieties like the Seville orange *C. Aurantium Linn*, the local sour orange hybrid *C. sinensis var*, the grapefruit *C. maxima var uvacarpa Merrill and Lee*, the rough lemon *C. Limonia osbeck* and the lime (both sour and sweet) *C. aurantifolia Swingle*, which produce polyembryonic seeds, i.e., seeds which contain several embryos, are likely to give a more uniform lot of seedlings than the pummelo *C. grandis osbeck* and the 'Nattaran' *C. medica var* which appear to have only one embryo per seed possibly the sexual embryo.

Very probably other important considerations as suitability to a locality, vigour, compatibility and disease resistance, may influence the selection of particular varieties as stocks but the desirability of using only pure lines of such stocks whether as seedlings or cuttings in order to secure the highest degree of uniformity cannot be gainsaid.

Once a suitable rootstock variety has been selected by experiment it will be necessary to establish groves in isolated areas and maintain the purity of the selected strain.

Thus it will be possible to build up three kinds of citrus trees for careful study and comparison. They are :

1. Scion variety on clonal rootstocks of seedling origin.
2. Scion variety on clonal rootstocks propagated vegetatively as cuttings, layers, stools or marcots.
3. Scion variety on its own roots.

For this purpose an attempt has been made to root citrus cuttings in a solar propagator at the Experiment Station, Peradeniya.

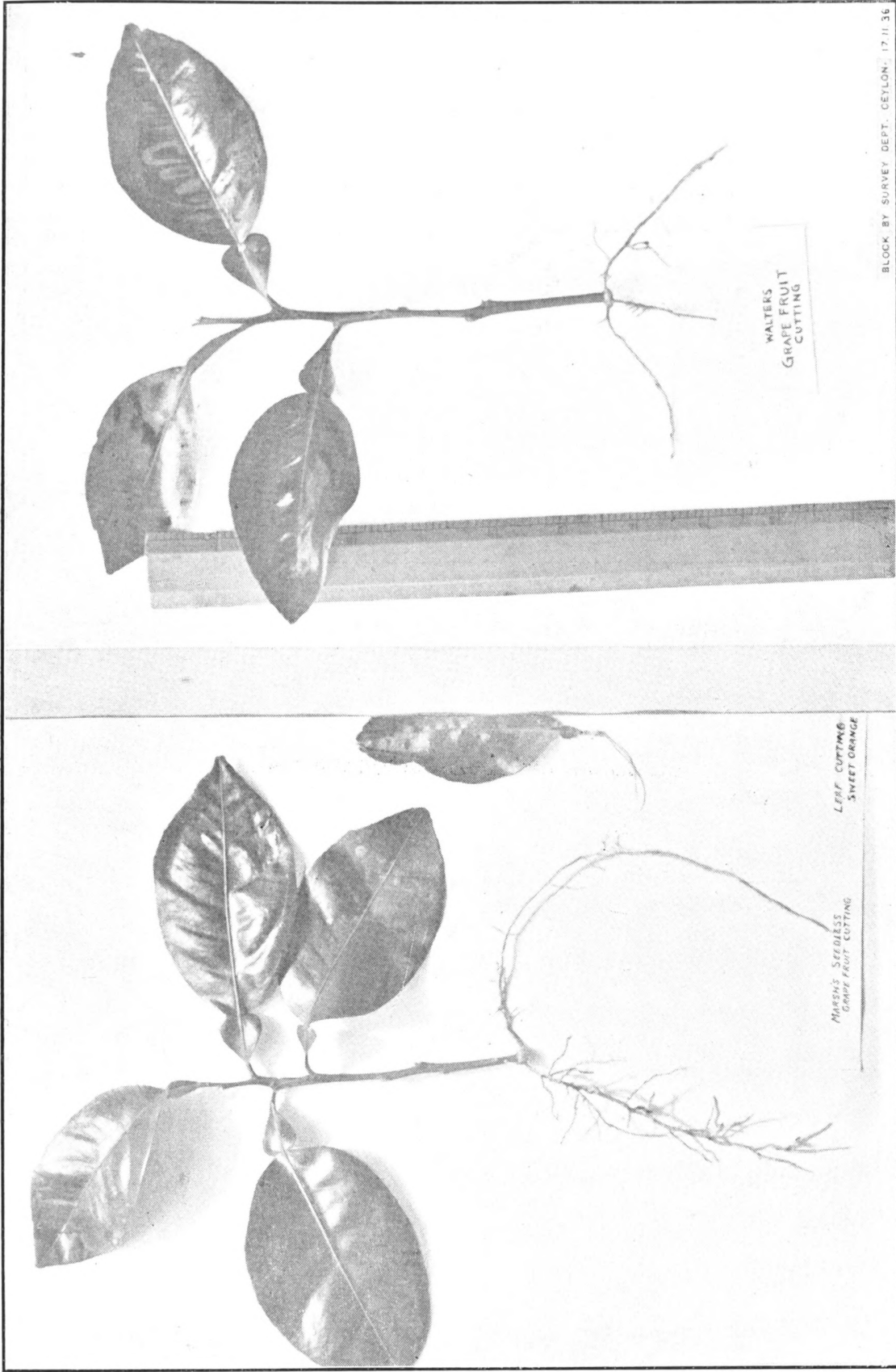


Fig. 1. Marsh's seedless grapefruit cutting
8 weeks in the propagator

Fig. 2. Walters' grapefruit cutting
6 weeks in the propagator

WALTERS
GRAPE FRUIT
CUTTING

MARSH'S SEEDLESS
GRAPE FRUIT CUTTING

LEAF CUTTING
SWEET ORANGE

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Fig. 3. Cuttings set in the propagator. Note the rooting habit of the Nattaran twig graft with a grapefruit scion

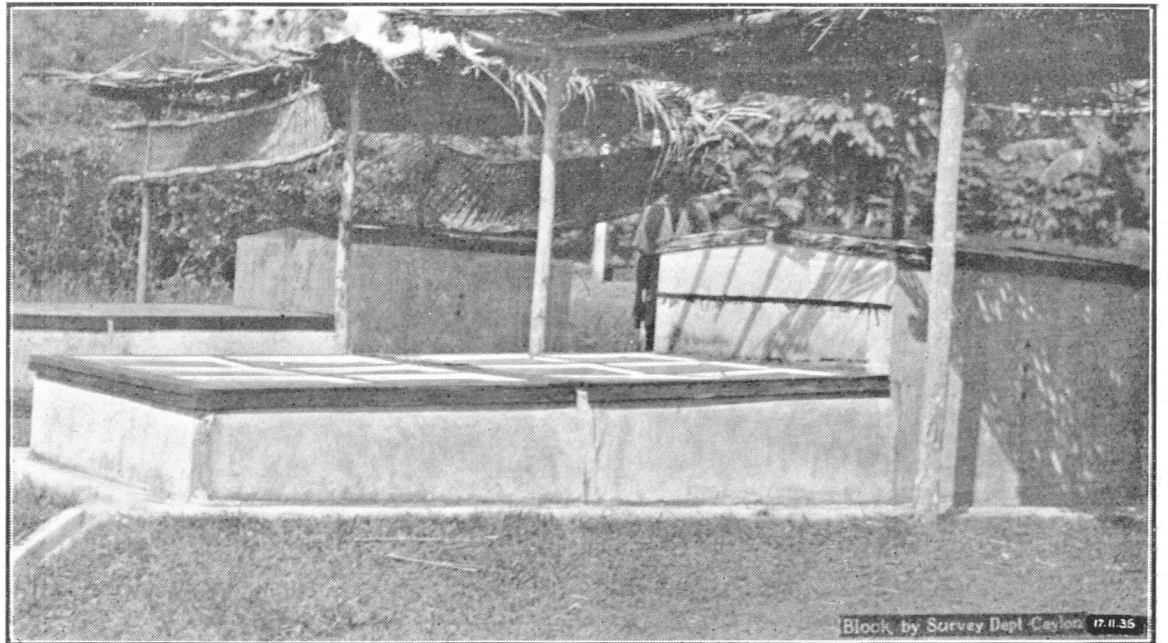


Fig. 4. General view of two solar propagators with overhead shade for the propagating chambers. The heating chamber which is exposed to the sun extends below the propagating chamber and is continuous with it

THE SOLAR PROPAGATOR

The propagator which is made of cement concrete is very similar to the one used by Hunter at Trinidad (5). It has been in use only for a short while but the results of empirical trials with softwood cuttings have been very promising.

In temperate countries the propagating bed is warmed up by means of steam or hot water pipes run through the bottom of the bed. This bottom heat is necessary to stimulate the cuttings to calluse rapidly and produce roots. Sometimes lanterns are used as in Kenya (6) to supply bottom heat for the rooting of coffee cuttings.

In the case of the solar propagator the heat is obtained at a minimum of expenditure from the sun's rays. Hence bright sunshine is essential for its efficient working.

The heat from the sun's rays is absorbed by the water in the heating compartment. At Trinidad a number of large stoppered glass bottles filled with water and painted black on the outside were placed within the heating chamber to absorb the heat. The heating compartment is a shallow tank five feet wide by fifteen feet long on the inside with exit holes for the water at ground level. There is a narrow drain all round it filled with water to keep off ants. Its lowest wall is one foot three inches in height and its two side walls rise up to a height of one foot nine inches at the point where it is continuous with the propagating compartment above. The glass sash covering it is thus given a tilt to allow rain water to run off.

A current of hot moist air rises from the heating compartment during day time and warms up the bottom of the rooting bed in the propagating compartment above. The rooting bed is kept fairly warm even at night since the heat retained by the water is given out very slowly.

The propagating chamber is about a third of the size of the heating chamber and is covered with two smaller glass sashes each working on a couple of hinges fixed to a wooden frame. There is a ledge inside the chamber to support the rooting bed at a height of one foot nine inches from the ground. Iron bars fixed into the wall at the same level serve as additional support to the rooting bed which is constructed by placing a

sheet of expanded metal in position and over it in turn wire netting, coconut fibre and coarse sand, to a depth of six to eight inches. The sand is well washed to get rid of all organic matter.

Adequate ventilation is provided through two one-inch holes in the side walls and also through other holes which allow of the insertion of thermometers to test the temperature of the rooting bed and the air above it.

Water is sprinkled on the rooting bed once a day early in the morning and the propagator is kept closed for the rest of the day to keep the air in the chamber moist.

Overhead shade is provided for the propagating chamber only in order to prevent the leaves inside from being scorched by the direct rays of the sun. There is however sufficient illumination for the leaves to manufacture carbohydrates which evidently are necessary for root formation.

With varieties like grapefruit, mandarin and orange which are difficult to root it is very important to see that the cuttings do not drop their leaves in the propagator. If this happens the cuttings will not strike. Overcrowding is definitely bad. Careful control must be exercised over the moisture content of the rooting medium and humidity of the air above it, so that the leaves may remain turgid and the sand round the cut ends not too wet to cause decay.

Coarse sand has given good results but the cut ends must be close to the moist fibre though not touching it. Fine sand however is likely to get saturated with the greater amount of moisture given out by the exposed water surface in the tank.

		TEMPERATURE					
		<i>Bright warm day</i>			<i>Dull cloudy and cool</i>		
		8 a.m.	11 a.m.	3 p.m.	8 a.m.	11 a.m.	3 p.m.
Temperature of air in the shade outside ..		27·6°C	28·0°C	32·3°C	25·0°C	26·4°C	30·5°C
Temperature of air in the propagating chamber ..		27·8°C	28·4°C	31·2°C	25·1°C	27·0°C	30·6°C
Temperature of sand		28·2°C	28·7°C	29·8°C	25·0°C	25·6°C	28·6°C
Temperature of water in the tank ..		31·8°C	32·5°C	34·0°C	29·4°C	29·8°C	31·4°C

It will be noticed that the temperature of air inside the chamber gradually rises higher than that of the sand as the outside atmosphere gets warm in the afternoon. Similar readings were obtained by Swingle and others (7), but they found that the surface of the rooting bed was usually slightly cooler than the bottom—'a condition much to be desired'—because of the evaporation going on.

THE CUTTINGS

Softwood cuttings eight to ten inches long which are really semi-hard wood in texture appear to be more suitable than hard wood material. They must have at least four or five leaves which have developed their full dark green colour. The secret of success lies in selecting the type of cutting which is likely to retain its leaves under the conditions in the propagator. Cuttings weakened by attacks of scale insects or with either mottled or chlorotic leaves or with tender leaves which will wilt and shrivel are definitely unsuitable. They must of course be free from disease.

Very little is known of the internal physiological condition of a cutting which is likely to root. Evidently it is determined to some extent by the age and vigour of the tree.

Halma (8) found it difficult to induce rooting of cuttings taken from orange trees declining in vigour but was very successful with cuttings from healthy vigorous trees. Varieties like the citron, 'Nattaran' and lemon root easily enough in the open ground from cuttings devoid of leaves, but in the case of the grapefruit, mandarin and orange, which are less accommodating, leaves are essential for root and shoot formation.

In one of the trials at Peradeniya a number of cuttings taken from Marsh seedless grapefruit trees were found to drop their leaves within a week in the propagator. In course of time they all began to decay without producing roots although they had callused freely round the cut ends.

As an experiment a few of the cuttings without leaves from a similar batch were at first splice-grafted to leafy 'Nattaran' scions and then placed in the propagator. A good many of these twig-grafts produced roots in course of time while the ordinary grapefruit cuttings which had dropped their

leaves began to decay without striking root. Later when these twig-grafts were planted out in bamboo pots the grapefruit stocks produced healthy shoots while the 'Nattaran' scion remained dormant on top (See Fig. 5 and Fig. 6).

It may be reasonable to infer that the twig-grafts were able to strike root because of some influence probably in the nature of a hormone or root-forming substance which came from the leaves retained by the scion. Whatever this scion influence may be, the fact remains that the 'Nattaran' variety which produces roots very freely is able to stimulate root production in a difficult subject like the grapefruit. Its ability to retain its leaves for a longer period may also be a factor which contributes in no small measure to success in rooting of grapefruit cuttings devoid of leaves.

Further experiments are in progress to elucidate this point and to consider possibilities of its wider application for the rooting of difficult citrus varieties.

'Nattaran' is a variety similar to citron. It will root readily in the open from cuttings devoid of leaves and like citron has a peculiar rooting habit in that the roots are not necessarily confined to the callus region but also appear from the stem higher up. The leafy shoots not only retain their leaves more tenaciously but also calluse freely and unite readily with the stock on which they are worked.

'Nattaran' cuttings have also been budded to grapefruit, mandarin and orange by the ordinary inverted T method, and then rooted inside the propagator. The buds remained perfectly healthy till the roots were formed and shot out when the cuttings were transplanted into bamboo pots (Fig. 7).

Quite satisfactory results have also been obtained by splice-grafting grapefruit and orange scions on to 'Nattaran' cuttings and then treating the twig-graft as cuttings in a propagator (Fig. 3).

In this way bud-grafts can be obtained in a comparatively short time of three to four weeks, but it remains to be seen whether the 'Nattaran' variety will prove to be satisfactory as a stock under local conditions.

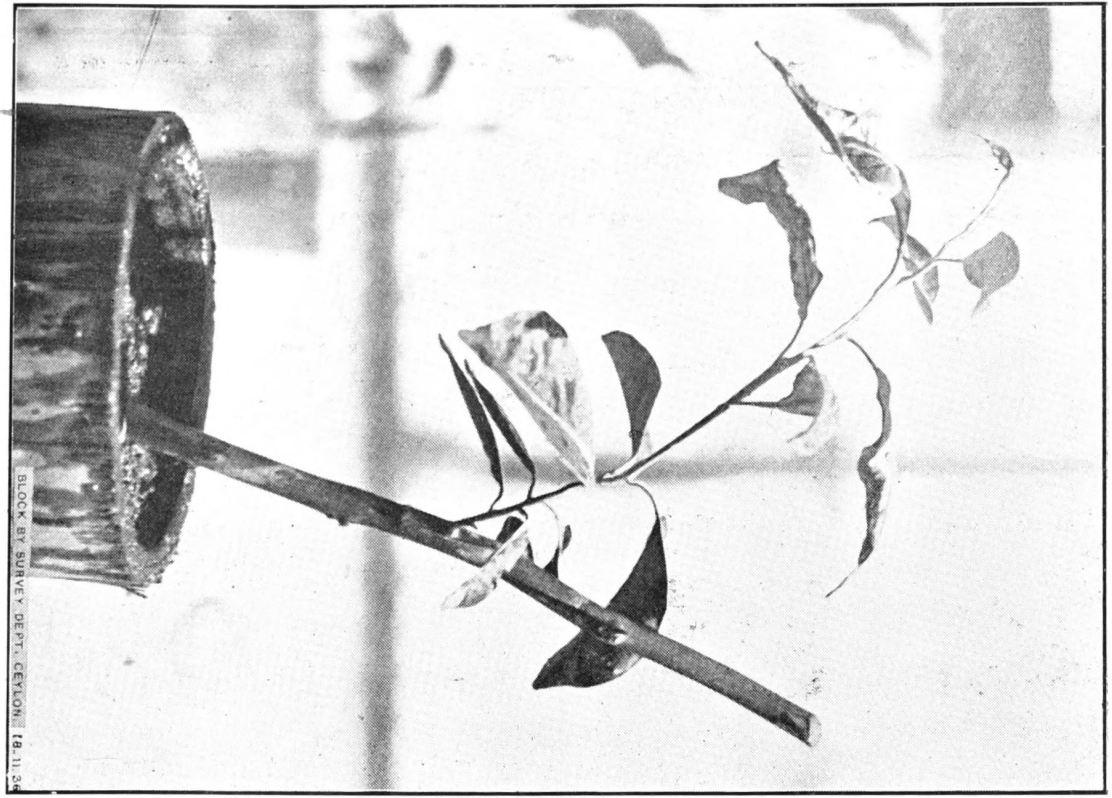


Fig. 7. Nattaran cutting budded to grapefruit and rooted in the propagator



Fig. 8. Closer view of the propagating chamber showing the wire netting resting on expanded metal. Below this extends the heating chamber containing water

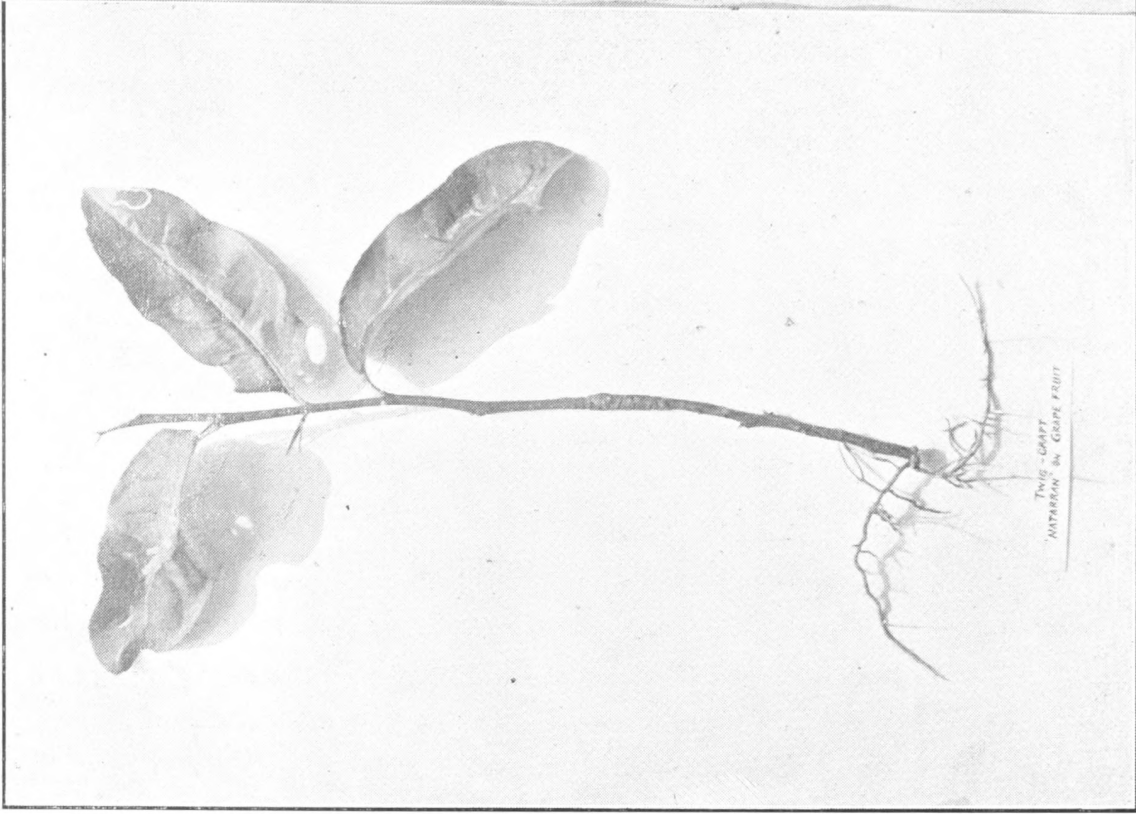


Fig. 5. Twig-graft. Nattaran on grapefruit (Marsh's seedless) 7 weeks in the propagator



Fig. 6. Twig-graft. Nattaran on grapefruit (Marsh's seedless). Note the two new vigorous shoots produced by the grapefruit stock 4 weeks after removal from the propagator

At the time of writing the following species and varieties have been successfully rooted in the propagator.

Seville orange.—*C. Aurantium L.*

Grapefruit.— *C. maxima, var. uvacarpa Merrill and Lee.*

Varieties : Ellen, McCarty, Triumph, Walters and Marsh seedless.

Orange.— *C. sinensis.*

Varieties : Local sour orange, Valencia Late, Mediterranean Sweet, Washington Navel, Jaffa.

Mandarin.— *C. nobilis, var. deliciosa Swingle.*

Varieties : Nagpur Santara, Chinese.

Lime.— *C. aurantifolia Swingle.*

Varieties : Sour—local and British Guiana, sweet and seedless.

Lemon.— *C. Limonia Osbeck.*

Varieties : Eureka, Lisbon and Rough Lemon.

Citron.— *C. medica, var. L.*

Varieties : 'Nattaran' and citron.

Calamondin.— *C. mitis Blanco.*

Shaddocks.— *C. grandis Osbeck.*

Varieties : Local pummelo, Mongibella, Isabella, California Wonder.

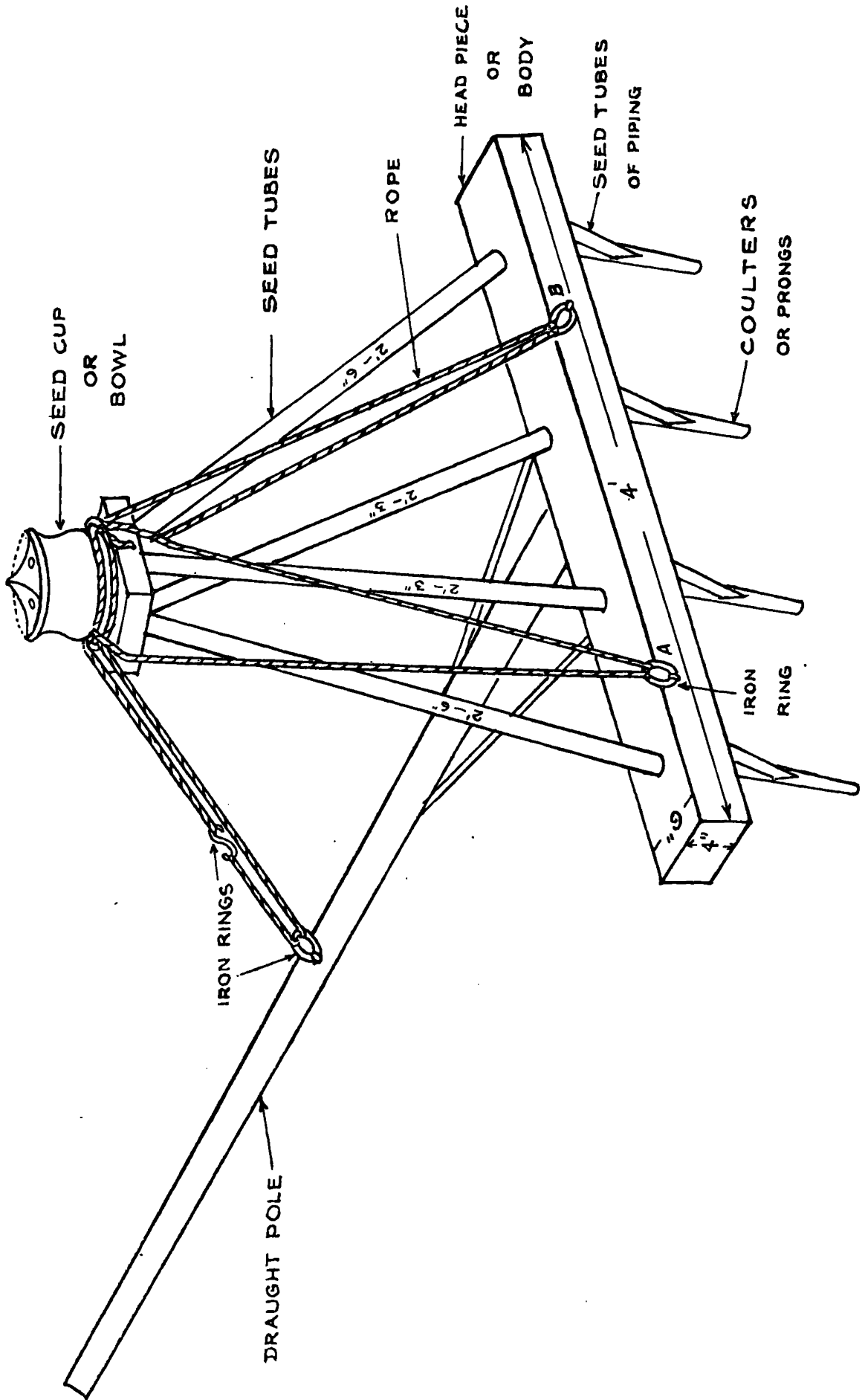
Practically all the varieties in citron, lemon and lime groups will strike from cuttings in the open.

Of the varieties of grapefruit, Ellen, McCarty and Triumph appear to strike more readily than Walters and Marsh seedless.

The mandarins require more bottom heat for satisfactory rooting. The local pummelo and the Seville orange are difficult to root but the varieties Mongibella, Isabella, California Wonder—classed tentatively as shaddocks—which were imported from India as 'own root' marcots and which have an extremely vigorous habit of growth coupled with appreciable resistance to canker, strike root readily in a month's time. They have not yet flowered, but they may prove to be valuable material for clonal rootstocks.

REFERENCES

1. Webber, H. J., 1932. Variations in citrus seedlings and their relation to rootstock selection, *Hilgardia* 7 : 1-79.
2. Webber, H. J., 1926. A comparative study of the citrus industry of South Africa. *Union of South Africa Dept. of Agric. Bull.* 6 (Imperial Bureau of Fruit Production, *Technical Communication* No. 3).
3. Strasburger, E., 1878. Ueber Polyembryonic *Jenaische Zeitschrift Naturwissenschaft*, 12-654.
4. Juan P. Torres, 1936. Polyembryony in citrus and study of hybrid seedlings. *Philippine Jour. Agric.* First Quarter No. 1.
5. Hunter, R. E., 1931. Citrus propagation. *Trop. Agriculture* 8 : 90-93.
6. Gillett, S., 1935. Vegetative propagation of coffee. *East African Agric. Jour.* 1 : 76-83.
7. Swingle, W. T., Robinson, T. R. and May, E., 1924. The Solar Propagating frame for rooting citrus and other sub-tropical plants. *U. S. Dept. of Agric. Circular* No. 310.
8. Halma, F. F., 1931. The Propagation of citrus by cuttings. *Hilgardia* 6 : 131-157.



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THE INDIAN SEED DRILL