AgroSpecial 1

A nurseryman and his trees

The work of John Maurice

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Rick Schuiling, Wageningen University and Research Centre, prepared slides and photographs for publication and Barbera Oranje, Agromisa illustrator, produced the drawings. Eva Kok, Agromisa staff member, assisted in the final editing.

Eva Maurice took a lively interest in the preparation of this publication. She provided most data for the biography and delved deep into the papers of her late husband to help answer our queries.

Abstract

John Maurice died in July 2002 after 50 years of tree nursery work in Israel. He had a way with plants and it seemed as though no woody species could resist being cloned by him. John had an uncanny feeling for creating a congenial nursery environment under harsh conditions and pioneered the propagation of 'mini-trees', including cultivars of a wide range of fruit and nut crops and selected progenies of species used in agroforestry.

Mini-trees are small and light (typically weighing 60 - 100 g), partly because they are delivered without pots or rooting medium. The small size is achieved by very early budding or grafting, keeping the nursery period shortened to one year. Moreover, as branching of the roots is stimulated rather than growth of the shoot, mini-trees have an extensive fibrous root system of youthful vitality. Consequently the tiny trees have a surprising ability to survive in transit (7 - 10 days if properly packed and kept out of the sun) and after field planting; even bare-rooted evergreens have proved to be extremely hardy!

John Maurice was familiar with conditions in the tropics from his earlier work on an ocean liner and as a fruit and coffee grower in Rhodesia (present-day Zimbabwe). As a nurseryman in Israel he of course realized that his mini-trees would be eminently advantageous in the Third World. From the 1970s he propagated nucleus stock for tree planting projects in developing countries, airfreight and phytosanitary requirements not being great impediments for the lightweight, bare-rooted trees. The success of these consignments led to invitations to demonstrate his techniques in countries in Asia and Africa (and also in Europe).

Until death overtook him John searched for ways to set up a central tree nursery in one or several developing countries, where the necessary skills to maintain collections of mother trees and to propagate superior cultivars and progenies of tree crops would be concentrated.

Neither poor infrastructure, nor heat or drought would prohibit the movement of mini-trees to remote districts. If necessary the mini-trees could be raised to a conventional size for field planting in a simple nursery within the district. And to make advances in tree crop breeding anywhere in the world available to developing countries, John envisaged an international network for the exchange of mini-trees. John did not live to see these dreams come true, although he demonstrated that his vision was no daydream closer to home: he was asked to establish a nursery in the harsh environment of the Negev desert.

This paper is written as a tribute to John Maurice, in the conviction that his propagation methods deserve wider application, particularly in the Third World. The methods are discussed in some detail and scrutinized according to the tenets of crop science. They are also placed in the context of developments in plant propagation in general. John's notions about the role of high quality nursery stock in engendering development in the Third World are presented. The operation of national plant quarantine stations and the Asian citrus rehabilitation programme are examples of activities that might benefit greatly from employing mini-trees.

Contents

1 Introduction

Every tree can be propagated true to kind - at least it seemed so, as long as John Maurice was alive. John died in July 2002, after nearly 50 years as a nurseryman in kibbutz Hazorea in Israel. He had a way with plants and woody species could not resist being cloned by him. That is why, for instance, CSIRO in Australia turned to him to solve the problem of cloning pistachio. To everybody's surprise John soon obtained a high percentage take in grafting this stubborn plant of the semi-deserts of central Asia. His approach in propagating tree crops was particularly relevant to developing countries and harsh growing conditions. In this paper we review the work of John Maurice to highlight the salient points of his approach and to assess its scope for tree crop development in the Third World.

Trees for the Third World

In many tropical regions the strenuous efforts to combat hunger are thwarted by deforestation, overgrazing and desertification. Eventually agronomists realised that in focusing on annual food crops they had neglected the important role of perennial plants, in particular trees and shrubs. Trees ameliorate the climate, reduce wind and water erosion, provide shade and shelter for man, beast and companion crop, and shape the landscape. Trees sustain the capacity of the land to feed people. To stop the trees losing ground, agroforestry was launched in the 1970s. This new discipline in agricultuaral science drew attention to auxiliary woody plants: trees and shrubs that serve as windbreaks, live stakes, hedges, etc. in addition to producing firewood, fodder, or other products not covered by the older disciplines: forestry, plantation tree crops and fruit growing.

People in the Third World generally have a great appreciation of the trees in their environment. They know them by name, are familiar with their uses and abuses and therefore tend to stick to the - often quite intricate - customs that govern ownership and exploitation. Thus, if trees disappear, there usually are compelling reasons, such as mounting population pressure, aggravated by migration and breakdown of traditional authority. In such situations tree planting projects face considerable odds; it is a great help if the project can demonstrate that its trees survive after planting and yield more than the trees the growers are used to.

The problem is to make planting material with these superior traits available in remote areas in developing countries and to make sure that the trees will survive in the prevailing conditions. John Maurice had a solution for this problem.

Chapters 2 and 3 describe the propagation techniques pioneered by John and the properties of the resulting planting material: 'mini-trees'. Chapter 4 gives an example of the application of these techniques under the exacting conditions of the Negev desert, showing also John's ingenuity in creating a congenial environment to nurse plants anywhere, taking advantage of the lie of the land and local materials.

Chapter 5 explains the special role that mini-trees can play in the Third World. John evisaged nurseries for mini-trees in a growing number of Third World countries exchanging superior progenies and cultivars. Within each country mini-trees with these desirable traits would find their way to regions with suitable growing conditions. John believed that putting this high-quality planting material in the hands of the growers would greatly stimulate rural development.

The concluding chapter assesses the achievements of a lifetime devoted to tree propagation. Several of John's propagation techniques have found wider application, but the value of mini-tree nurseries in the Third World is still to be tested. A few suggestions for such a test are put forward.

2 Propagation techniques

The roots come first

John Maurice was a self-taught, practical man, managing a commercial fruit tree nursery. He was not a research worker. Over the years his methods evolved by trial and error, not by formal experiments in which new methods were compared with the old ones. Therefore we must judge from what we have seen with our own eyes and from John's few published writings, which of the multitude of materials and methods he employed were essential to his success and which were extraneous or indeed just blind alleys. In so doing we keep in mind John's starting point, one which he never abandoned: in propagating a tree the roots come first. According to John nursery stock, whether evergreen or deciduous, should leave the nursery without pots, the root system being sturdy enough to permit bare-rooted delivery to any destination, even to remote regions in the tropics.

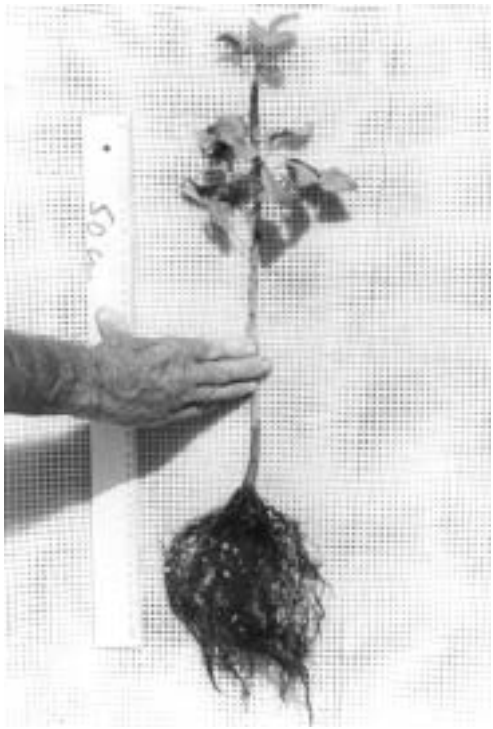

Figure 1: Nursed to survive transit and transplanting: topgrafted pistachio cv Lassen. Note: the emergence of many roots at the root collar; the low shoot:root ratio; graft placed high on the rootstock.

Consider the implications of this approach to plant propagation:

no pots:	they are either too small to accommodate the roots or too big, the transport being prohibitively costly;
no soil:	its heavy weight makes transport cumbersome and expensive and impedes trade across borders because of phytosanitary requirements;
visible roots:	free from defects so often hidden by the pots, such as poorly branched taproots, roots circling in the bottom of the pot or torn off in their search for soil outside the pot, potbound roots.

Few nurserymen would quibble with John's starting point - it is a truism. However, in conventional nurseries - with plants raised in the field or in pots - the roots are out of sight nearly all the time and attention tends to centre on the plant tops. Containers are filled with a rich mixture, containing much organic matter. But the organic matter decomposes, the medium settles and becomes compacted, depriving the roots of air and reducing water-holding capacity, the edges of pliable plastic containers fold over, so that water runs off instead of penetrating the pot... Timely repotting is the answer, but this is a lot of work. Degradation of the mixture can be slowed down by using more persistent media, such as shredded coconut fibre, but this requires much more attention to mineral nutrition. It is fairly common for potted rootstocks to stay in the nursery for 2 years before the grafted trees are ready. Under tropical conditions these plants must be repotted several times regardless of the substrate used.

It is possible to put root growth first in the case of field-grown or containerized stock, but compared to conventional nursery practice, John's approach is no less than a revolution: he lifts the roots out of the soil and out of the pot. As long as plants stay in the nursery the roots grow in a medium elevated above ground. Whereas the conventional nursery bench has a closed bottom, John's medium is supported by an open mesh or lattice. As soon as the roots have traversed the layer of substrate, their growth is stopped by exposure to the air. This

stimulates the emergence of side roots, at the expense of growth of the shoot: root growth does come first!

Air-pruning of roots

Germinating seeds first issue a taproot. By 1980 John was convinced that growth of this taproot should be arrested as soon as possible. He established a routine of germinating seeds in plastic mesh trays, only 5-6 cm deep. Hence the taproot is stopped almost immediately and adventitious roots emerging at the root collar take over (See Figures 1 and 2). We have tried this approach on a range of tropical fruit and nut crops - after all it is quite easy - and were surprised by the abundance and speed of adventitious root growth.

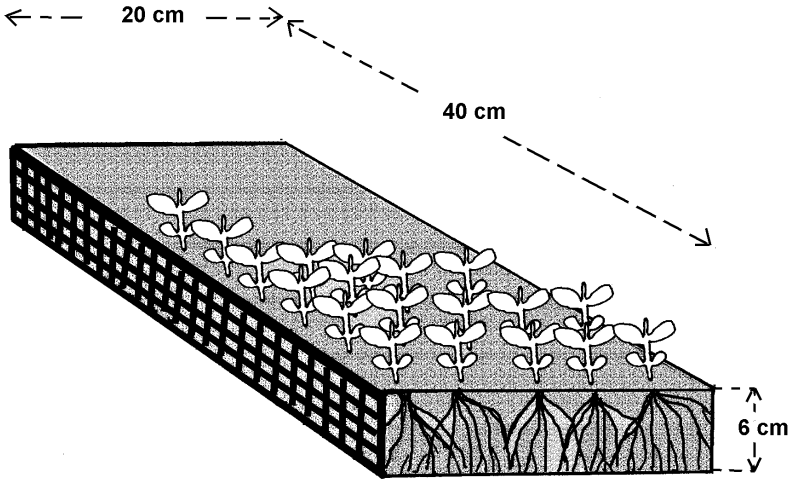

Figure 2: Diagram of germination tray with young seedlings.

John Maurice was not the first to adopt air-pruning of roots. In vegetable growing, where one large batch of seedlings follows another because of sequential planting throughout the season, the urge to increase propagation efficiency led to the replacement of germination trays by trays containing tiny pots or 'plugs'. These plugs fit in holes in larger pots into which they are transplanted. The plugs have no bot-

tom to ensure air-pruning of the roots and initiation of side roots capable of exploring the larger pot volume after transplanting.

In the course of the 1970s this led to the development of integrated systems for raising, handling and planting vegetable seedlings (Todd, 1982; Huang & South, 1981). Nowadays several such systems are applied commercially to ornamental bedding plants as well as vegetables. However, the plants are handled in pots. Moreover, because the plugs are very small and moisture cannot move from one to the other, protected cultivation and a sophisticated watering system are essential. John's germination trays may stand in the open as well as in a glasshouse, provided they are shaded against the hot sun. The free drainage and shallow depth of the trays calls for frequent watering, but even water distribution is not critical. (Until the seedlings emerge a mulch cover over the trays helps to even out moisture levels; the mulch also conserves moisture.) One soon learns which number of seedlings per tray allows unrestricted emergence of adventitious roots.

For tree crops Frolich reported as early as 1971 that stopping extension of the prominent taproot of plants of semiarid regions by germinating the seeds in a screen bottom tray virtually eliminated losses of plants after potting up. This report may have gone unnoticed, because later experiments with air-pruning of tree roots dealt with trees in large containers with openings in the sides and/or bottom to expose the roots. Although the effects on root growth and root distribution were generally favourable (e.g. Marler & Willis, 1996), these piecemeal attempts were a far cry from the systems-approach to propagation, handling and planting of bare-rooted evergreens which John worked out (Verheij, 1982). Starting off in the same way as Frolich by stopping the growth of the taproot almost as soon as it emerged, John continued air-pruning and did not use pots throughout the entire nursery period.

Raising seedlings and cuttings

The speed of germination of different tree crops varies greatly, but once the taproot emerges the adventitious roots take over in a matter of about two weeks and reach the underside of the substrate. The seedlings are transplanted once the adventitious roots have formed and most of them have been air-pruned at the bottom of the tray.

In the course of 25 years John Maurice used a great variety of media and supports to raise seedlings and cuttings. However, in essence the roots could grow to a greater depth (15-20 cm) than in the germination trays and on reaching that depth were again 'air-pruned', leading to further branching of the root system. Since the plants were not potted up, but had a 'communal' rooting space, additional root pruning was required to prevent root systems of neighbouring plants getting intertwined. Thus, after transplanting as well as in the germination trays, there was much emphasis on intensive branching of the root system within a confined space.

One way of nursing seedlings and cuttings - which, with slight modifications, proved a lasting success from about 1980 onwards - is based on transplanting in the same trays as are used for germination. The trays are stacked in a slanted position one against the other on a nursery bench, each tray containing a single row of plants along the top of the tray (see Figures 3 and 4). Roots which reach the wire-mesh bottom of the bench, some 20 cm below the top of the tray, are air-

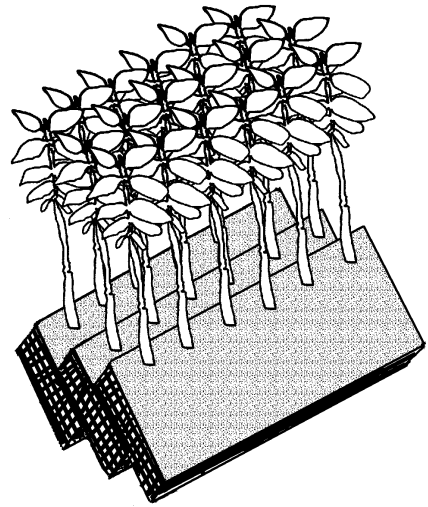

Figure 3: Seedlings transplanted along the top of the trays.

pruned. Other roots grow into the neighbouring tray in the stack. These roots must be pruned. This can be done by slicing through with a knife or by pulling each tray in succession a few centimetres out of the stack to rupture the young roots. The effort is minimal if done every fortnight, the roots still being quite tender. Both the air-pruning and the mechanical pruning stimulate further branching of the root system. An experiment with this nursing method in East Java, Indonesia, in which different local materials were compared as rooting media for 7 fruit crops, showed that both growth of the shoots and the roots are affected by the medium, the best root systems being formed in coconut fibre (see Figure 5).

Figure 4: Open top nursery bench with trays stacked in a slanted position. Undergraduate thesis work, Brawijaya University, Malang, East Java.

Rooting media

John experimented with a wide range of media, but the materials he used are all well known in the nursery trade. For many years he

worked mainly with peat or hardwood sawdust, mixed with compost. The sawdust was heaped on a sheet of pvc and left outside in the winter rains. As soon as grasses began creeping over the heap, he considered the material sufficiently weathered for use as a growth medium. He also used the coarser hardwood shavings. In the 1980s, however, he concluded that hardwood was too variable and prone to nitrogen deficiency and switched to a mixture of tuff, local soil and composted sewage sludge. John also used perlite and vermiculite and, in the 1990s, mixed peat, vermiculite and shredded coconut fibre, the latter gradually becoming the main or sole ingredient, with slow-release fertilizers to provide nutrients. Coconut fibre dries out rapidly and requires frequent watering. John preferred lightweight material, well aerated and free draining. Moreover, because plants were usually delivered bare-rooted, cleaning the root system by rinsing in water should be easy.

Figure 5: Jackfruit seedlings raised in coconut fibre (left) and local soil (right). Plants in coconut fibre have by far the largest root mass and the lowest shoot:root ratio. Thesis work as in Figure 4.

Early budding or grafting

As soon as the seedlings settled after transplanting John Maurice would try to bud or graft, to be able to deliver a grafted plant within one season from sowing the rootstock. His haste was again based on his starting point: the roots come first. One growing season is quite long enough to obtain an extensive root system and the short period in the nursery reduces the risk of deterioration of the roots. It also saves time and money by eliminating the need for potting or repotting...!

John noticed that grafts take more easily if roots grow moderately, not too vigorously or too sluggishly. By stimulating early branching the vigour of the taproot is dissipated over numerous side roots. Furthermore, by grafting when the roots are still young and active, you avoid the danger that loss of vitality of the root system will reduce the take of buds or grafts.

Figure 6: John grafting a tray of macadamia seedlings alongside the bench on which they are growing

Budding low on the rootstock is the preferred method for young stock, because for grafting one usually has to wait longer till the rootstock is thick enough to match the diameter of graftwood. A thick or flattened stem basis facilitates budding; patch budding is relatively easy on the flat side of the stem of *Canarium* spp. (e.g. pili nut, kenari nut). One of the standard methods for cocoa is patch budding on 3-week-old seedlings (Yow & Lim, 1994). This is a surgical operation, but working conditions have been standardized - each seedling is put in exactly the same position in front of the seated budder - and the success rate is generally high. The hypocotyl of durian is so thick and young shoots are so slender that cleft grafting on the decapitated hypocotyl is possible 5 - 6 weeks after sowing.

Budding low on the stock is not always possible, successful or desirable. The rootstock may need to be long, for instance to prevent spores of *Phytophthora* splashing up to the susceptible scion, as in the case of avocado on a rootrot-tolerant rootstock. John frequently resorted to grafting and used various techniques to graft young rootstocks. If necessary, he would repeatedly cut back twigs on the mother tree to induce a proliferation of thin young shoots to be used as graftwood, (e.g. avocado, mango, pistachio, carob).

In conventional nursery work grafts as well as buds are set low on the rootstock because there the stem is thickest and sturdiest. However, John did not want to waste most of the rootstock growth and tried to graft fairly close to the tip, also because in his experience younger tissues unite more readily. It is possible to match the thickness of stock and scion nearer to the tip: as the seedling grows, the stem thickens even near the tip because the apex is initiating ever larger leaves that need to be supported. John was not afraid of working with delicate material. In fact he himself spoke of ‘micro-grafting’. At times the grafts were so minute that he used a toothpick as support!

Typically, micro-grafting as practiced by John refers to grafting on very slender stocks (3-4 mm Ø). Advantages: fast healing, superior union and shortening of the nursery period. For some crops the plant-

ing material would be ready in a single season, a stem diameter of 8-10 mm being attained in 10 months.

Micro-grafting

The term 'micro-grafting' is more appropriately used in tissue culture, particularly to clean up virus-infected material (Navarro et al, 1990). It takes time before newly formed cells are infected by a virus; therefore if the shoot tip - usually only a fraction of a mm long and dissected under a binocular microscope - is grafted onto a healthy seedling the grafted plant may be virusfree. The success rates tend to be low but they improve rapidly if longer scions are used. Thimmappaiah et al (2002), for instance, obtained only 0.5% take of cashew shoot tips of 3 - 5 mm in length, but 79.5% for scions of 5 - 15 mm. Scions of such lengths are no option if material has to be freed from virus infection, but the finding is in agreement with the high success rates obtained by John with scions of one to several cm (and without the help of controlled growing conditions in a tissue culture lab).

John attributed the excellent results of his micro-grafts to the pliable nature of young tissues and preferred to graft or bud when the rootstock and the graftwood were both very young. (He explained the abundant initiation of adventitious roots in response to very early stopping of the growth of the taproot in the same way.) There may be a parallel here with the success of tissue culturing, which is largely based on the capacity of meristematic tissues to differentiate into new organs.

If the mature twigs were still too thick, John resorted to green grafting, using young, leafy shoots. Green grafts, like softwood cuttings, require high humidity to prevent drying out and removing or halving some of the leaves to reduce transpiration. Moreover, such tender material is commonly raised 'under double glass', i.e. in a glasshouse with an extra glass or polythene cover on the bench in which the plants are set. Condensation under the cover indicates that the ambient air around the plants is saturated with moisture. Alternatively, the plants may be raised in a glasshouse under mist, a sensor between the plants triggering a discharge by the mist nozzles when its surface dries up. (Budding on young, very 'green' seedlings does not require high

air humidity because the bud is taped in, so it is far less exposed than a green graft.)

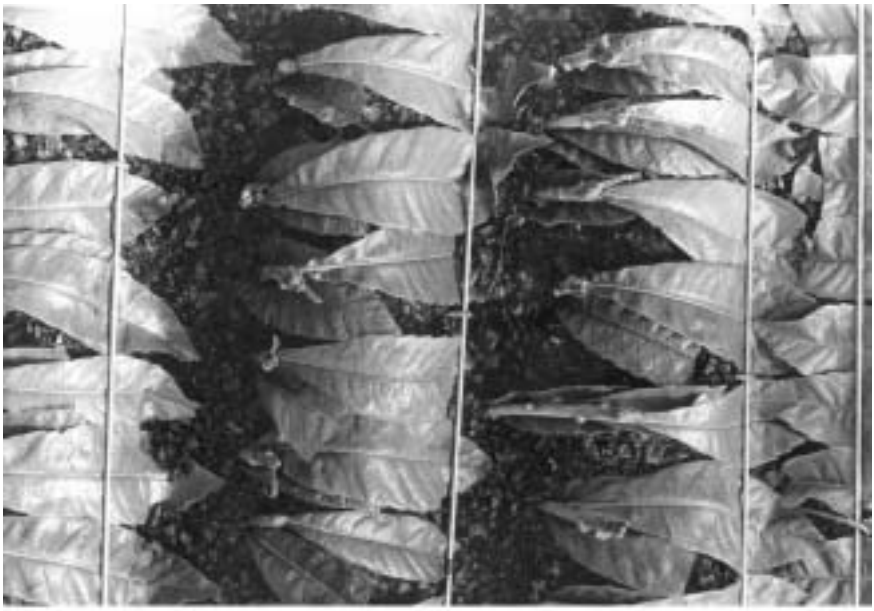

Figure 7: Cuttings of loquat - which do not root easily - inserted under an angle, so that the retained leaves rest on a ridge of moist sawdust to prevent wilting; the leaves are held in place by a wire.

John, however, managed without such sophisticated environmental controls: he would put the plants in a slanted position, resting the leaves of the cuttings or grafts on a ridge of moist sawdust, and providing overhead shade (Figure 7). His contention that the leaves could absorb the required moisture from the sawdust was borne out by the high rate of take. In the hot and dry Israeli summer he successfully experimented with misting over (!) a polythene tunnel covering the plants. This ensured evaporative cooling as well as raising the humidity; it also prevented leaching of nutrients from the leaves, a serious problem in case of frequent and prolonged misting.

3 Mini-trees

In the previous chapter we looked at the propagation techniques. Here we consider the preparation for dispatch and the properties of the resulting nursery stock, such as the small dimensions and the hardiness.

When the (grafted) trees are lifted, the roots are washed to remove the substrate and dipped in a gelling substance to prevent drying out. The mini-tree is now ready for dispatch (Figure 1, Chapter 2). Alternatively the roots may be given a mud coating by dipping them in a clay slurry. One way of packing the trees is to make bundles of trees by rolling them tightly in a plastic strip, leaving both the top side and the root side of the bundle open for ventilation (Figure 8). The bundles can then be packed in a carton, insulated by a layer of polystyrene foam. An example of such a shipment was the collection of 340 fruit trees carried as cabin luggage (!) in a citrus box from Israel to Tanzania via Amsterdam in 1972. The trees were cleared by Dutch and Tanzanian customs officers without a hitch, inspection and clearance being greatly facilitated in the absence of potting soil.

In a single growing season a grafted plant does not reach a size that is customary in the nursery trade. In his later years John Maurice was so confident that the vitality of his well-branched fibrous root systems could be maintained, that on request he also nursed planting material for a second year. Because of their minute size John called his nursery stock mini-trees.

The mini-trees are indeed tiny, weighing only 60 - 100 g; plants nursed for a second year weigh 300 - 500 g. Compare this with conventional planting material, commonly weighing 500 - 2000 g bare-rooted; if the trees are potted one to several kilogram has to be added for the potting soil. In terms of transport the difference is dramatic: a headload in combination with a bus ticket instead of hiring a van... And just consider the savings on airfreight!

Figure 8: Mini-macadamia trees with flat root systems being rolled in polythene before dispatch. In this - unusual - case the substrate has not been rinsed off the roots.

Standard-size planting material, particularly evergreens raised in pots, is too cumbersome to be carried over long distances. In other words: the production and sale of such trees requires a well-developed infrastructure with adequate nursery expertise at the local level and efficient communications and transport facilities to reach the growers. (There may be scope for mini-trees even in such a favourable environment, for example tree nurseries supplying mini-trees to garden centres where they are raised to a range of larger sizes according to the demands of customers.)

However, in large parts of the world the above requirements cannot be met. John saw clearly that mini-trees would be particularly valuable in the Third World, where the lack of infrastructure, aggravated by vast distances, makes the distribution of conventional potted plants often impractical. He felt that mini-trees are ideal for the Third World, both at international and domestic level:

- Third World countries can extend their collections of mother trees by flying in mini-trees of promising cultivars or progenies;
- mini-trees produced within the country can reach outlying regions in good shape where standard-size nursery stock is not an option.

John himself amply demonstrated the potential of mini-trees at international level: over the years John sent lots of trees abroad. We traced consignments for the following countries: Ethiopia (a collection of grapes and stone fruit with low chilling requirements); Tanzania (a collection of 340 fruit trees); Mexico (a few thousand mini-trees); Indonesia (low-chilling stone fruit); Spain (pistachio); Gabon (a few hundred mini-trees); Nigeria (a collection of apple, stone fruit and sub-tropical fruit cvs). Mini-trees of a wide range of crops are listed in one of his publications (Maurice, 1984): avocado, citrus, cherimoya, guava, loquat, feijoa, persimmon, jujube, olive, walnut, pecan, macadamia, pistachio, carob, oak and *Prosopis* species and the tropical fruits mango, cashew and mangosteen.

For anybody planting trees, be it a hedge, a fallow crop, an orchard or a village forest plot, the main consideration is of course successful field establishment. In remote areas where the timely arrival of a consignment of trees is often a triumph of organizational skills, nothing is more discouraging than failure of an appreciable percentage of the trees. Apart from the waste of effort, it necessitates gap filling and results in an uneven stand, which complicates management of the plantation. Hence, for the successful production and distribution of mini-trees within a country, their hardiness is as important as their small size.

Mini-trees are hardy. Their survival is based simply on John's starting point: the roots come first. The high proportion of roots is as striking a feature as the small dimensions of the trees. In the absence of destructive measurements we cannot give figures for the shoot:root ratio but one only needs to see mini-trees to be convinced that this ratio is much lower than in conventional nursery stock (See Figure 1, Chapter 2). The low shoot:root ratio is a natural consequence of continuous

root pruning in the nursery, which diverts energy to the emergence of new roots at the expense of growth of the top. The slowing down of shoot growth is to some extent compensated by minimizing losses of the rootstock shoot, both in budding (as this is done very early) and in grafting (preferably done close to the tip of the stock); in both cases hardly any shoot growth of the rootstock is wasted. Early budding/grafting in turn produces a saleable mini-tree within one growing season, which means that the roots are young and vigorous. Trees from conventional nurseries are generally much older when they leave the nursery. Too often their high shoot:root ratio is aggravated by loss of vitality of the roots in the absence of root pruning.

Thus, although tiny, mini-trees are also robust: the high proportion of roots and their youthful health contribute to survival both in transit and after planting in the field. The trees of the above consignment for Tanzania spent a long weekend in the Netherlands, so more than a week passed from being packed in Israel till they were all planted at the national Horticultural Research and Training Institute (HORTI-Tengeru) near Arusha. With the exception of the persimmon trees, all trees grew happily after planting, losses were negligible. For some reason the persimmons went dormant, but they did not die: they too resumed growth after about a year (Verheij, 1982).

An added advantage is that the mini-trees with their flattened root systems do not require large planting holes. John recommended a mere slit in the ground made with a spade to insert the flat root system. If watering is needed, just a little water will do to settle the soil around the roots. Thus labour requirements for planting are minimal.

In Tanzania the mini-trees were planted under favourable growing conditions. An opportunity to test the mini-trees under truly harsh conditions presented itself when the Ben Gurion University asked John to supply planting material for a research programme in the Negev desert.

4 A nursery in the desert

At the Avdat Experimental Farm in the Negev desert the Ben Gurion University investigated the scope of run-off water harvesting for arid zones in the Third World. The trees and shrubs under investigation were both typical agroforestry species (e.g. *Leucaena leucocephala*, *Prosopis juliflora, Cassia sturtii, Acacia salicina, A. nilotica*) and fruit and nut crops (e.g. pistachio, pecan, macadamia, persimmon). John faced a real challenge there because not only was he expected to supply the mini-trees, he was also requested to produce them on the spot! So John moved to Avdat and set up a nursery. This desert nursery is an excellent example of his approach to propagation, including his skills in ameliorating the environment with simple means.

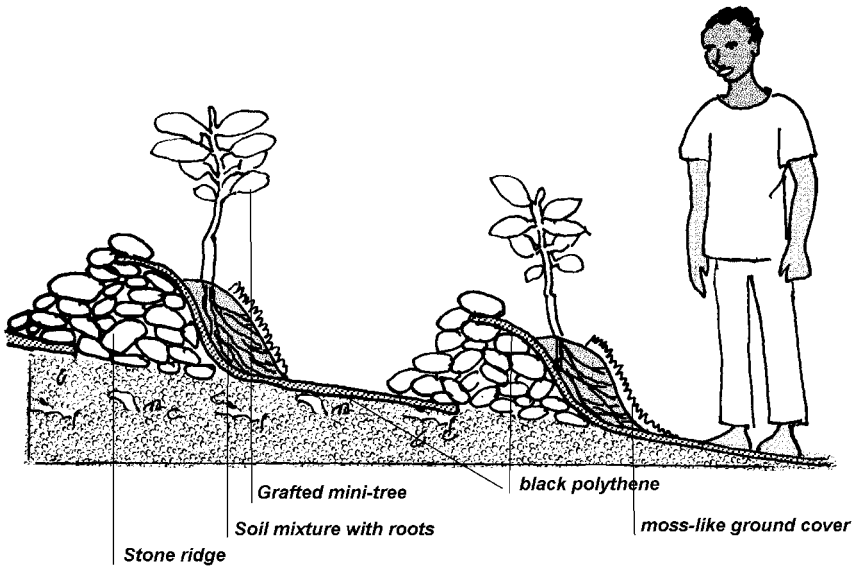

Figure 9: Diagram of ridged nursery rows on a slope.

John laid the nursery out by forming ridges of soil mixtures along the contours on a north-facing slope; the northern slope effectively

reduced solar heating of the ridges. Each ridge was constructed on a 1.5 m wide strip of heavy black plastic, curved upwards on the south side and kept in place by stones piled against the ridge on that side, as shown in Figure 9 and Figure 10. The stones faced the sun, absorbing heat in the daytime, thus further reducing the maximum temperature in the ridge. During the cold desert nights, the stones released heat to prevent excessive cooling of the ridges which formed the nursery rows.

On the north side of the ridges, a moss-like ground cover (*Helxine soleirii*) was planted to stabilize the soil. *Helxin*e, used as an indoor potplant, is a perennial that does not spread aggressively. Its frail roots do not interfere with the roots of the nursery stock and do not hinder lifting of the plants. Moreover, it does not attract foraging wildlife nor suffer unduly from pests and disease.

Its main limitation was its preference for more humid conditions; that is why it would only grow on the north side of the ridges (where it also benefitted from the shade cast by the nursery rows). On the other hand, the moisture transpired by the *Helxine* helped to cool the ridges during hot spells, which are likely to occur in desert habitats.

The young seedlings germinated in 6 cm deep mesh trays as described above (see Chapter 2, Figure 2), were transplanted in narrow slits made in the top of the ridges before the start of the hot season. In this way the initial root system could be flattened to a convenient shape for packing when the plants leave the nursery. As the roots grew they reached the plastic, following it till they were air-pruned at the perimeter of the ridge, leading to further branching of the roots. A blunt knife was also pulled through the ridge between the trees, in order to separate the root systems of adjacent trees and to induce further adventitious root growth.

Seedlings were budded (near the base of the stem) or grafted (at a somewhat later stage, near the tender tip) as early as possible, in some cases even in the germination baskets before transplanting. However,

John also experimented with grafting early in the second year in the nursery, having cut back the mother trees in the winter to induce leafing out of numerous thin shoots to be used as graftwood. In one of his papers (Maurice, 1984) John gives details of the budding and grafting techniques for the fruits and nuts.

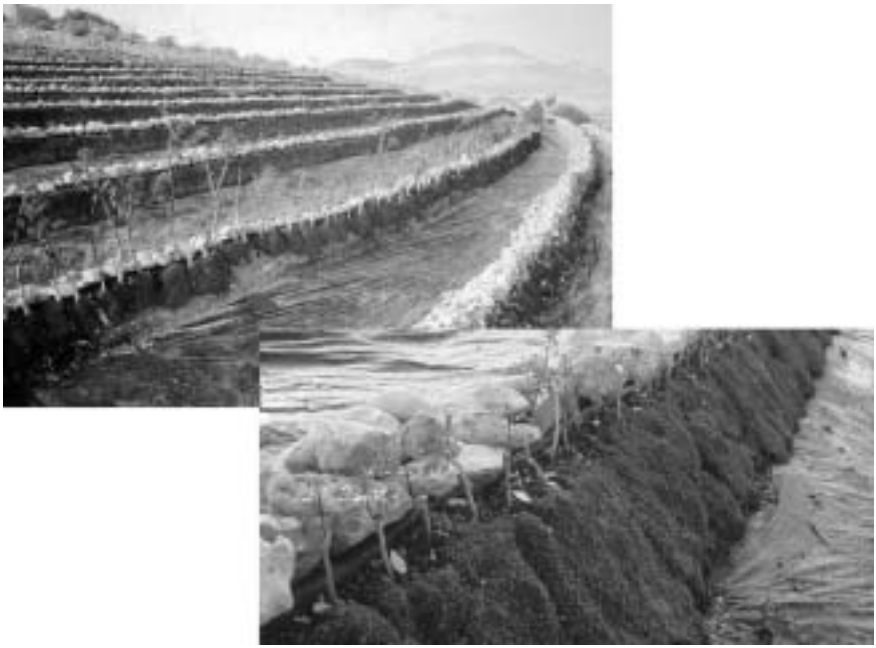

Figure 10: General view of the nursery and close-up of the ridges with trees.

Bundles of 5 or more trees were wrapped in moist paper and perforated polythene for despatch, outer packing and insulation depending on the duration of the journey and conditions on the way. The roots were submerged in a mud solution before planting, the mud filling in and adhering to the root mass to form a flat root plate. A simple slit in the ground sufficed to plant the tree and only a little water was needed to settle the soil around the roots. Mulching, with stones or trash around the tree base completed field planting.

When, one year after field planting, the root systems of *Pistachia atlantica* (the pistachio rootstock) were laid bare with a water gun, the roots were found to have extended in all directions, with a few dominating anchor roots which replaced the missing taproot.

Perhaps the success in creating a congenial environment to nurse plants in the harsh Avdat desert requires a person of John's exceptional skills. But where he succeeded even with fruit and nut crops which are hard to bud or graft, others should not find it too difficult to grow seedlings for use in agroforestry under such adverse conditions, or to raise mini-trees to a more conventional size for field planting in a secondary nursery. Also, the results at Avdat confirm that the mini-trees, which at first sight might appear immature and delicate, are in fact extremely hardy.

5 High quality trees for remote areas

John not only supplied trees that had been nursed to survive; he also wanted the Third World to benefit from the advances in fruit growing and agroforestry through breeding. The trees he dispatched by air to countries in Europe, Africa, South-East Asia and the Americas were trees with desirable traits. Planted in a suitable region they were expected to be an improvement on the locally available material. And he anticipated that these trees would engender a chain of development not unlike the 'green revolution' in some major staple crops in the 1970s. And all these trees would extend their ameliorating effects on climate and soil, on man and beast ...

From 1945 until 1951 John was a fruit grower in Rhodesia. At that time the tropical fruits - with a few exceptions such as banana and pineapple - had not yet been touched by science. The level of fruit growing depended on the experience accumulated by generations of growers, who by and large had to make do with seedlings or locally available varieties.

The situation changed when John moved from Rhodesia to Israel where he was well placed to observe the changes. Developments in the sub-tropics were a strong stimulus, because many fruits grown in the sub-tropics are also important in the tropics, e.g. citrus, avocado, mango and several annonas, or have potential in the tropical highlands, e.g. grape or pome and stone fruit with low chilling requirements. Outstanding collections of fruit crops from various parts of the world could be found in Israel. The country was in the forefront of research work on these crops, and the link with the tropics was strengthened by Israeli scientists working in developing countries. That is in fact how John became involved in the propagation of fruit and nut crops for the Third World.

Scarcity of water is an overriding concern in Israeli agriculture. Much research work is directed towards water-saving cultivation methods and irrigation systems (e.g. trickle irrigation). Water can also be saved in fruit growing by using drought or salt-tolerant rootstocks (e.g. for citrus and avocado). John took a lively interest in these innovations and, as explained in Chapter 4, he himself contributed by establishing a nursery in the Negev desert. The success of that nursery convinced him that mini-trees could be produced virtually anywhere and the excellent results following planting in the field proved the superior hardiness of his tiny plants.

Through his involvement in these developments John was aware of the discrepancy between the seedlings and indifferent varieties he grew in Rhodesia and the superior clonal fruit and nut cultivars and rootstocks now available. He felt that Third World countries should have access to this improved material to assess its usefulness in suitable agro-ecological zones. He was convinced that a breakthrough in productivity was within reach, in particular, for many tropical fruit and nut crops.

John believed that improved matching of the diverse tropical fruit and nut crops with the diverse tropical growing conditions would give each region a competitive edge in growing and marketing at least one or two of these crops. He foresaw a real impact on the development of rural areas if only superior clonal material, adapted to the locality, could be made available on the spot.

This is where John saw a golden opportunity: produce outstanding clonal mini-trees in a central nursery in a Third World country and send them to outlying areas where tree-planting projects are in operation. In the project area the mini-trees could be raised in a simple nursery to a convenient size before being planted by the growers. And - in the grand international socialist tradition - he envisaged a growing network of these central nurseries in ever more countries, so that the world's best stock would become available to everybody in the form of mini-trees. All the expertise for propagation can be concentrated in

the central nursery; for the secondary nurseries in remote areas the supervision of an extension worker suffices.

Towards a breakthrough in productivity in fruit growing in the tropics

In the tropics trees tend to grow vigorously, attaining a large size. This increases their impact on the environment and is fine where fodder or wood products are to be harvested. However, the lush growth is incompatible with good flowering and fruiting of most tree crops. Frequent flushing leaves the buds no time to differentiate flowers, and fruit set suffers amidst vigorously growing shoots. Moreover, many forms of crop care (e.g. pruning, crop protection, hand pollination, selective harvesting) become virtually impossible if trees are large. So the grower seeks to reduce the vigour of most fruit trees in order to balance it with flowering and fruiting.

John saw that vegetative propagation of more fruitful selections is the crucial step towards attaining a more favourable balance between growth and fruiting. Ideally, it leads to a cascade of effects:

- High-yielding trees are selected for propagation
- The juvenile period, inherent in a seedling, is eliminated, so that the trees come into bearing within a few years from planting
- Precocious cropping means that energy is diverted from shoot growth to fruit growth early on, limiting the increase in tree size
- A good crop suppresses flushing of new shoots from fruit set to harvest, giving the buds on quiescent twigs time to complete flower initiation and differentiation for next season's crop
- Limited tree size allows closer planting, so that there is a strong cumulative effect of higher yield per tree and more trees per hectare
- Small trees can be more intensively and efficiently managed reducing production cost per kg.

Properly packed, the mini-trees can travel for a week or longer, even under extreme tropical conditions, without watering or care other than keeping the cartons out of the sun. The excellent root systems ensure rapid resumption of growth in the outlying nurseries and after field planting.

The idea is simple and John did not find it difficult to convince people who visited his nursery or worked with his mini-trees. He received international recognition from professional people and organisations. The standard textbook on plant propagation (Hartmann et al, 5th ed. 1990) qualifies John's mini-trees as 'promising' and acknowledges

their potential in the tropics (but these authors comment only on the small size of the trees; they do not mention the superior root system which contributes so much to survival after field planting).

John's simple idea - a central nursery backed by secondary nurseries in different agro-ecological zones - becomes more complicated when the necessary supply of good seed or superior budwood, cuttings, etc. is considered. For clonal propagation a collection of mother trees of the different cultivars is needed. The mother tree collection can be planted at the central nursery, the main requirement being good vegetative growth; profuse flowering and fruiting is not needed. Adequate maintenance and administration of mother tree collections, including supplementing the collection with promising new accessions, is at least as demanding as the propagation and distribution of the mini-trees. The central nursery needs to be equipped for this task. In due course the central nursery should be able to guarantee that its mini-trees are true-to-type and free from pests and diseases, which requires the assistance of specialized scientists.

For propagation by seed, seed gardens of selected trees need to be established in agro-ecological conditions conducive to flowering and fruiting. For species which do not produce seed in the central nursery, seed gardens might best be planted at secondary nurseries, since these are likely to be located in different agro-ecological zones. Secondary nurseries of course need not be limited to raising mini-trees sent by the central nursery. Rather than sending seed from its seed gardens to the central nursery, and waiting for the resulting mini-trees to come back, the scope of secondary nurseries can be expanded to include the production of mini-trees from material in its own seed gardens. This enables workers at the secondary nurseries to gain expertise and opens up opportunities for further activities, lessening the dependence on centralised services.

John travelled far and wide - to Asia, Africa and Central America - to observe growing conditions and to propound his ideas, even in his 80s. He simplified the layout to the point that a nursery could be set

up with local material anywhere. Consignments of mini-trees went to countries in all 3 continents and did extremely well, and time and again there were initiatives to set up a central nursery in one country or another. However, the necessary combination of initiative, finance, expertise and continuity failed to materialize. John did not live to see his ideas properly tested in a few tropical countries however hard he tried. In fact he was as anxious that mini-trees should contribute to a larger role for trees and tree crops in the Third World as he was diligent in searching for alternative methods to raise the mini-trees.

Mini-trees and the development of a fruit industry

When undernourished people get enough to eat, attention shifts to the debilitating effects of malnutrition, i.e. a shortage of what nutritionists call 'protective food': protein, vitamins, and minerals. Fruits and nuts are important sources of protective food, so John reasoned: let fruit and nut trees shape and protect the environment and let people's health benefit from eating more fruit and nuts. People generally like to do so, but few people can afford to buy enough as most fruits and nuts are quite expensive because the trees are shy and erratic bearers. However, a break-through in productivity based on the introduction of superior clonal planting material, as discussed above, opens up new perspectives. Higher yields and lower production costs bring prices down, making fruit growers more competitive, boosting consumption, and expanding markets.

Looking even further ahead, John hoped that the production of a few crops would increase sufficiently to preserve surplus fruit (e.g. by drying) or to store the nuts with a view to trading the products in distant markets. The nurseries, the expanding orchards, the processing and storage of the products and the resulting trade would all generate employment, much of it very suitable for women. Wishful thinking? Perhaps, but the very purpose of propagating superior cultivars, nursed to survive under the prevailing field conditions, is to stimulate developments of this kind.

John saw a similar perspective for other groups of woody plants. He hoped for instance that the rapidly increasing body of agroforestry knowledge would bring hitherto undervalued auxiliary woody species into the limelight. Species that would be planted as hedges, windbreaks, improved fallow crops, etc. and which produce more fuel wood or better forage, particularly under harsh growing conditions. Mini-trees would of course be the way to introduce such species into remote areas.

6 Conclusion

This paper is a tribute to John Maurice, a modest man whose devotion to his nursery plants led to important - and in several respects revolutionary - insights into plant propagation. The production of grafted bare-rooted evergreens with an exemplary root system, capable of travelling for a week or 10 days without loss of vitality is a real breakthrough. His exceptional nursing skills also deserve recognition. For instance the elegant (though labour-intensive) methods to display the leaves of softwood cuttings or green grafts so that the undersides are in close contact with moist substrate, and his ingenious and simple techniques to create a congenial environment in the nursery (the example of the Avdat nursery in the desert could be supplemented by several others).

Some elements of his approach, in particular, the germination in shallow open trays to obtain intensive rooting near the collar, and budding as early as possible after germination of the rootstock, have found wider application. However, the integral system of propagation, based on nursing without pots or containers, continuous root pruning, and shortening the time spent in the nursery by grafting near the tip of the stock or early budding, has to our knowledge not been tried by anyone else. The principal reason may be that planting material of trees is usually graded according to size, the trees with the largest stem diameter commanding the highest price. This custom is of course a major obstacle for the acceptance of mini-trees in the trade. But John's mini-trees are not meant for the customary nursery trade. Their strength lies in:

- The ability to endure long transit periods from nursery to destination
- The spectacular savings on freight when transported over long distances
- The excellent survival, in spite of the delayed field planting, even in harsh environments.

This is the niche where mini-trees are far superior to conventional nursery stock, because the grower has to pay less and can rely on successful field establishment.

Figure 11: The dove with the olive branch: tree nursed to survive in the harsh desert.

John was a man with vision: he saw clearly where the potential for mini-trees is greatest. His vision was that his small clonal trees with their excellent root system, which had never seen a pot or container, would travel to remote corners of the world. For instance to corners where overexploitation of the environment threatens the survival of communities and where tree planting is one of the few options which might turn decline into sustainable progress. His vision was that these communities would not be supplied with indifferent planting material, but with the best possible material, propagated by the best-qualified staff in a central nursery in the country. He was confident that such superior planting material could be supplied at a competitive price, as a result of the simple nursery lay-out, the short propagation period and the minimal cost of transport and handling of the mini-trees.

Whereas exporting mini-trees from Israel to far-away countries was a great success, the result John so ardently tried to achieve proved elusive: nurseries in the Third World producing mini-trees to facilitate expansion of fruit growing and agroforestry.

As far as we know there have been no concerted efforts by government agencies or private persons to set up a nursery for mini-trees in the Third World. Failure to succeed might have to be accepted, but we find it hard to accept that such a splendid idea has not even been properly tried. So to end this presentation of John's achievements and expectations, we give two examples of existing organizations that might test mini-trees to great advantage.

An obvious candidate is the national plant quarantine station found in virtually every country to control the importation of plants. Where it is common policy to release only the offspring of imported plants, a nursery might propagate mini-trees of all woody plants at the quarantine station. In doing so offspring could be released within the shortest time possible and would have excellent chances of survival, even at remote destinations.

In many Asian countries a multi-tier nursery system is being established with the help of FAO to make healthy citrus stock available throughout the country (Aubert, 1990). At a foundation nursery heat treatment and micro-grafting eliminate virus infections and the debilitating greening disease. In successive tiers this healthy stock is bulked up until in the last tier - in the centres of production - private nurseries can meet the demands of the growers for various types of citrus. In countries such as China, Indonesia and the Philippines the planting material has to be transported over large distances from tier to tier. Production of mini-trees could result in faster multiplication and substantial savings in transport cost. Citrus is usually planted bare-rooted, so the saving on freight is less spectacular than it would be for potted plants. However, even small gains in efficiency are of great importance in view of the large numbers of plants involved: Aubert (1990) estimated that 12 million trees were needed annually between 1990 and 2000 to prevent a decline in the citrus area in South-East Asia; in view of the anticipated expansion of the citrus industry this number was expected to double. If growers prefer conventional planting material it would still be very worthwhile to produce mini-trees to stock the successive tiers.

Perhaps these two examples provide clues for other situations where mini-trees offer clear-cut advantages, for it is our conviction that John's achievements in plant propagation deserve wider dissemination and that his ideas about application of the techniques he pioneered and the benefits of mini-trees in the Third World merit proper testing.

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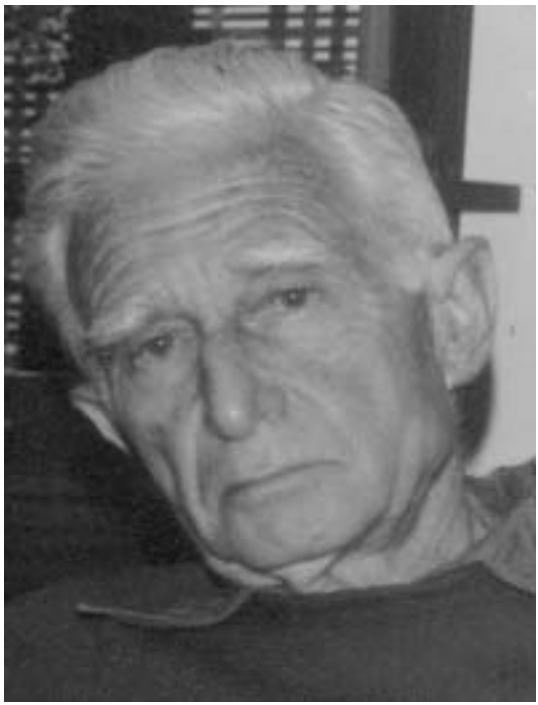
Brief biography



John Maurice was born on 29 March 1914 in London, UK. He grew up in a well-to-do family as indicated by the final stage of his general education: after completing the High School, City of London, he attended a finishing school in Lausanne, Switzerland. To the surprise of his colleagues the french he learned there surfaced again during a mission to Gabon in 1995, when John was 81!

It took time before John found his calling in horticulture. He started off in 1931 as an apprentice with Sexton, Son & Edward, shoe manufacturers in Norwich and London where he worked for three years. The link between the cobbler and the later nurseryman is that in both professions deft handling of the knife is required. Breaking out of the confinement of the shoe shop, John took to sea, sailing with ss 'Viceroy of India' as a crew member from 1935 until 1936.

Having sailed around the globe he returned to London for his initiation in horticulture: in 1936 he was employed by John Russell Ltd., Plant Propagators, Belsize Park. Apparently he felt he had found his niche because his next move was to the David Eder Training Farm in

Harrietsham, Kent. This farm trained people intending to emigrate to Palestine both in communal life and agriculture.

In 1939 John married Eva Rieser. It was also the beginning of the Second World War. John served with the Royal Air Force from 1940 until 1945, first as paramedic and later as interpreter. After the war the couple settled in Southern Rhodesia (Zimbabwe), where John took over Bonny Eagle Orchards at Melsetter and thus became a fruit grower. The three children were born at the farm while John began his pioneering work with tropical tree crops; he also served on the Soil Conservation Board of the Eastern District. He experimented with methods to dwarf trees in order to establish high-density orchards. Blue Mountain Copper Tip coffee was introduced by John and in the 1990s the farm was still a Coffee Research Station.

In 1953 the Maurice family settled in Israel as members of kibbutz Hazorea. When - much later in life - asked about his reasons for the move, John said that he saw no future for his children in colonial Rhodesia. After his adventurous early years, this was John's last move. He found work in the orchards and the commercial fruit tree nursery of kibbutz Hazorea and became manager of the nursery in 1954, a task he fulfilled till his retirement in 1980. And after that he just kept going, using the deteriorating nursery facilities and trying where possible to humour the kibbutz by incorporating products from the plastics factory, the financial mainstay of the kibbutz.

John's nursery work and his diligent efforts to contribute to development of the Third World is the subject of the foregoing paper. Here, only a few salient events from these 50 years are related. John's outstanding nursery skills and unremitting drive to experiment made him a highly esteemed partner of research organisations, both in Israel and abroad. John greatly enjoyed this recognition of his work by scientists, but satisfied growers were his greatest reward.

In 1969 John set up an avocado and mango nursery in Nir Yizhak, in the western Negev, on behalf of the Israeli Nurserymen's Association. Hence his work in establishing and running a nursery in Avdat in 1986 and 1987 was not the first time he grappled with the challenging growing conditions in the Negev desert. In 1979, sponsored by the Harvard University and the Missouri Botanical Gardens, USA, and accompanied by Dr James Aronson, he embarked on an ambitious tour to Costa Rica, Mexico, Hawaii, China, Nepal and India, trying to create a network of Hazorea-style nurseries for the production of mini-trees in these countries. Recently Dr Aronson, looking back on this tour, commented: "We did not succeed in this task. We were premature by at least 20 - maybe 40 - years, for a variety of reasons. John's vision of a nursery network remains for future generations to fulfil."

In 1980 John spent 6 weeks in the Horticultural Research and Training Institute in Tengeru, Tanzania, to impart his skills to staff and students at the institute. His unflagging energy, fired by the appreciation and enthusiasm of his trainees, impressed everybody. He was not concerned about food, drink or lodging, as long as he could spend the day in the nursery or the field with a few keen Africans. In 1987, seconded by the Ben Gurion University of Tel Aviv, he lectured in Spain and helped to establish pistachio orchards in Portugal. His last visits to tropical countries were in 1995: he was a member of a mission to Gabon which formulated a project for the development of fruit growing and later that year he went to Thailand to conduct a course in propagation techniques at the national Horticultural Research Institute at Chantaburi.

John's zeal did not diminish his ability to put things in perspective. With a wry sense of humor he wrote in a 1998 letter: "It isn't easy managing the nursery. Rumours seem to have spread that its purpose is for research of the dietic preferences of stray donkeys. Then there are insect problems. Visiting entomologists are always delighted and amazed at their numbers and destructive ability. These pests presumably abandoned surrounding nurseries in disgust, and found better quality cultivars here. Surprisingly there are also snakes around, although I

would not have thought that any self-respecting snake would want to be found dead in this nursery."

John carried on steadfastly regardless. In 1999 he gave a lecture on his latest mini-trees, featuring 'pocketbook-size root systems' in Oregon, USA. In 2001, the year before he died, he proudly showed further improvements in nursing these trees.

John Maurice died, 88 years old, on 30 July 2002 at Hazorea. He is survived by his wife, his children and his trees.