ISSN 0312-8997

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Price $20.00

WANATCA YEARBOOK • Volume 20 • 1996

WANATCA Yearbook 1996

Eriobotrya japonica, the Loquat (see page 24)

West Australian Nut and Tree Crop Association (Inc)

Yearbook 20 • 1996

Registered by Australia Post: Publication WBH 0868 ISSN 0312-8997

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West Australian Nut and Tree Crop Association (Inc)

WANATCA Yearbook

Volume 20

1996

Cover Picture (the Loquat) from Tropical and Subtropical Fruit *by B.E. Dahlgren*

West Australian Nut and Tree Crops Association (Inc.)

PO Box 565, Subiaco, WA, 6008

Publications

The Association publishes a quarterly magazine *Quandong* and the *WANATCA Yearbook*. Members receive these publications of the Association as part of their current year's subscription.

Membership

For current details of membership contact the Secretary, WANATCA, P0 Box 565, Subiaco, WA 6008, Australia (e-mail: wanatca@AOI.com.au). Members are welcomed from within and beyond Western Australia, indeed about one third of the current membership is from outside Western Australia. Overseas members are encouraged, and pay only standard fees.

For further details of the Association, see Inside Back Cover

WANATCA Yearbook: ISSN 0312-8997; Supplement to Quandong: ISSN 0312-8989

Typesetting and design: Tree Crops Centre, PO Box 27, Subiaco WA 6008
Printed in Australia by Optima Press, Perth

THE BIRD'S MESSAGE -
COMMERCIAL CROPS WITH MINIMUM INPUT

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Abstract

Local, small-scale studies carried out over the last few years indicate the possibility of a dramatically improved approach to nutrition of tree crops.

The approach is based on 3 factors - foliar application of trace elements, maintenance of a thick, coarse organic mulch, and complete withholding of fertilizer applications to the soil. Results to date indicate that yields comparable to those from standard commercial methods can be obtained from as little as 5 grams per tree per year of trace elements.

In an effort to understand how such results could be possible, a detailed investigation has been made into all the factors which appear to be involved in tree crop nutrition. Biogenic processes in soils, particulate matter in the air, and holistic micro-environmental conditions all appear to play a part.

The new approach appears to have some valuable potential spinoffs in such areas as reduced water needs, mixed-species tree cropping, environmental sustainability, and lesser sensitivity to soil pH and salinity, apart from the inherent savings in lower fertilizer and labour costs.

Introduction

Readers with good memories, going back far enough, may remember a ribald kid's ditty which was along the following lines.

A little bird, flying high
Dropped its message from the sky
"Well! said the Fly, wiping its eye
Blooming good job cows don't fly."

What I am going to look at here is some work which suggests that, in some sort of sense, it would be a good job if cows did fly.

Over the last 6-7 years, I have been working on an approach to tree crop nutrition which has given me some quietly amazing results. Amazing because the ratio of positive outcome

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to input has been exceptionally high - in essence, I have been able to obtain what I would regard as commercial yields from crop trees with the application of less than 10 grams of fertilizer per tree each year. Quiet, because the technique I have evolved requires considerable patience, with it taking perhaps a year to give convincing evidence that the method is working, and then, watching results improve continuously over following years, wondering for how much longer the regular improvement can continue.

There are three parts to this technique:

1. *Apply a very dilute trace element spray to the leaves of the trees at periodic intervals.*
2. *Maintain a thick, coarse mulch, resembling forest litter, under the trees.*
3. *Apply nothing else at all to the ground surface, except water.*

Of course there is nothing especially new about any of these treatments, although some of the details in my methods may be new. For a lazy person like myself this low-labour approach has come very naturally. For a keen professional grower, the hardest part may be number 3 - if 1 and 2 give good results, surely adding some manure or fertilizer will give even better ones?

That this last opinion is not necessarily true may require some explanation, and in fact I have put a lot of thought into how you can possibly get such good results from such little input. But first, a little more detail on the technique.

1. Trace element spray

I have a large suburban block in Perth on infertile grey sands - our local sand soils are notoriously mineral-deficient, some being 99% silica, pure enough to make glass with. I apply the trace element spray through one of those bottles (Fig. 1) which fits on the end of a garden hose - our mains pressure is good and the spray will reach to the top of fair-sized trees, such as the pecan in my yard. I have a big range of several hundred different fruiting plants from all over the world, plus a lot of ornamentals and natives, and everything gets the same treatment.

The mix I use is as shown in Table 1. The spray bottle is supposed to dilute this down by a factor of 20, so that is 50 gm in 40 litres of water, just over 0.1 % strength. Each bottle full will cover at least 100 plants, so each plant gets about half a gram of fertilizer per application. I aim to do the spraying once a ·month, but in practice manage it about 6 times a year, about 3 grams per plant per year - almost a homeopathic dosage.

There is nothing magical about this particular formula, which has been arrived at only by feel. An organic formulation could be used. I am not adding any phosphorus, though there will be some in the 'Thrive'.

Table 1. Trace-element mix
(Parts by volume)

'Thrive' soluble fertilizer	*5*
Potassium nitrate	*2*
Zinc sulphate	*1.5*
Magnesium sulphate	*1*
Manganese sulphate	*1*
Copper sulphate	*0.5*
Boracic acid	*0.25*

Use 10 spoons of the mix (about 50 gm) in the 2-litre spray bottle

2. Mulch

I use a thick mulch made up of leaves, sticks, bark, and chopped-up tree prunings, almost all of which originates on the property - I have a lot of trees and am always hacking bits off them and mulching them up. This sort of mulch is long-lasting, taking months or years to break down, and many of my trees will have their surface roots growing actually in the mulch.

3. Nothing Much Else

Apart from the foliar sprays and the hacking and mulching, the only other addition is water. I have a bore which delivers rusty Perth ground water, and use it for about 8 minutes a day for half the year, an average of 4 minutes a day.

Results

This technique seems to work well with all my plants, of the most varied types, and grown together in a multi-storey 'companion' planting.

Species include conventional temperate, subtropical, and tropical fruits and nuts (almond, plum, black walnut, pecan, macadamia, citrus, loquat, mango), and many unusual plants both native (Bunya, *Araucaria bidwilli*; Ball nut, *Macadamia praealta*; Candlenut, *Aleurites moluccana*) and exotic (Kei apple, *Dovyalis caffra*; Lingaro, *Elaeagnus philippensis*).

Fig. 1b. Spray bottle in use

The technique has improved or initiated yields on many crops, for example yields on a macadamia brought from about 2 kg to about 16 kg/year, pecan from almost nil to 15 kg/year, good crops on pomelo, fig, oranges etc. Spending less than 10 cents per plant per year, I seem to be getting yields similar to those of a commercial grower.

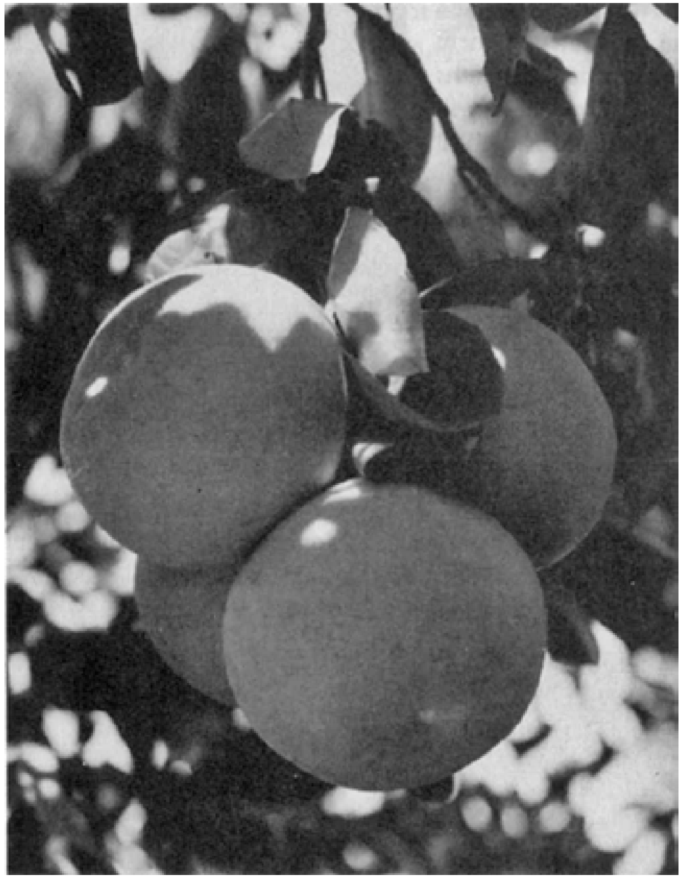


Fig. 2. Over 5 kg of fruit in this bunch of pomelos

The positive results of this technique seem to be:

- *Heavy flower induction and set*
- *Improved fruit yields*
- *Adequate leaf growth*
- *Reduced water needs*
- *Improved disease and pest resistance*
- *Improved cold resistance*
- *Good for mixed, multi-storey plantings*
- *Good acceptance of soil structure (sandy, clay)*
- *Good acceptance of soil acidity, alkalinity*

- *Organic approach possible*
- *No leaching offertilizers into water table*
- *Minimum fertilizer costs*

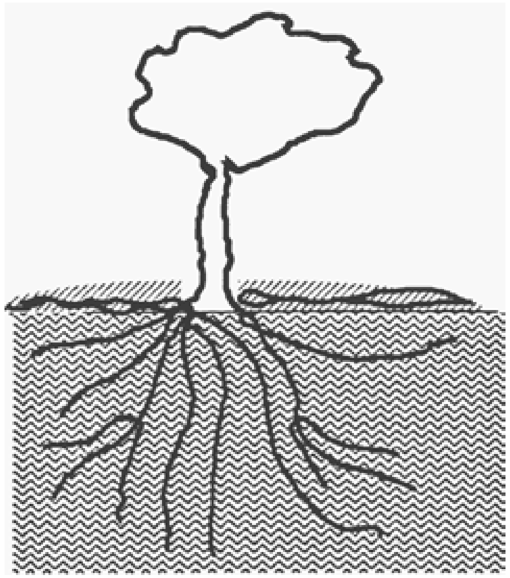
The negative factors are:

- *Patience required*
- *Not all fruits benefit from heavy fruit set*
- *Does not promote rapid leafy growth, eg vegetables, young trees*
- *Need to maintain suitable mulch*
- *Difficult to separate out effect of different spray formulations etc*
- *Most effective. only when the trees have leaves*

I have worked out the following series of explanations as to how this technique could be so effective.

Explanation 1: Nutrition where it's needed

First let us look at the different parts of an active fruiting tree (Fig. 3). This figure represents a fruit tree growing in the soil. Suppose that it is quite a large tree, a pecan perhaps, and occupies a square 10 metres by 10 metres, and its roots grow 5 metres deep. The soil used by the pecan will then occupy 500 cubic metres, and weigh over 1000 tonnes.



Suppose that the tree itself, or at least its woody part, weighs 1 tonne. The leaves on the pecan will weigh only a small part of this, certainly no more than 100 kg, and perhaps only 10 kg.

What I am suggesting, is that in the conventional approach to fertilizing, you are attempting to add enough fertilizer to bring 1000 tonnes of soil, that is a million kg, up to the desired chemical content.

On the other hand, if you apply the needed materials directly to the leaves, the plant's factories where these chemicals are actually mostly used, you need only add enough to bring these leaves up to the desired levels. That is, you are working on a scale ten thousand or a hundred thousand times smaller. Hence the great efficiency of putting your trace elements directly where they are needed.

Component	Mass (kg)
Soil	1 000 000
Wood	1000 (0.1 %)
Leaves	<100 «0.01%)

Explanation 2: Water to carry nutrients up

This same scenario can also explain how water needs could be much reduced. Estaban Herrera, a US pecan expert, has pointed out that a great deal of irrigation water must be applied to pecan trees because this water carries up from the soil the plant nutrients which the trees need.

If these nutrients can be applied directly where needed, on the leaves, this could greatly reduce the need for irrigation. I suspect that if the technique of fertigation, that is applying fertilizer as part of the irrigation water through under-tree sprinklers or emitters, was modified so that the water was dropped down on the leaves of the tree, much less water and fertilizer would be needed. It is also worth noting where any excess fertigation water goes -- down to the drip line, the traditionally recommended place to apply fertilizers.

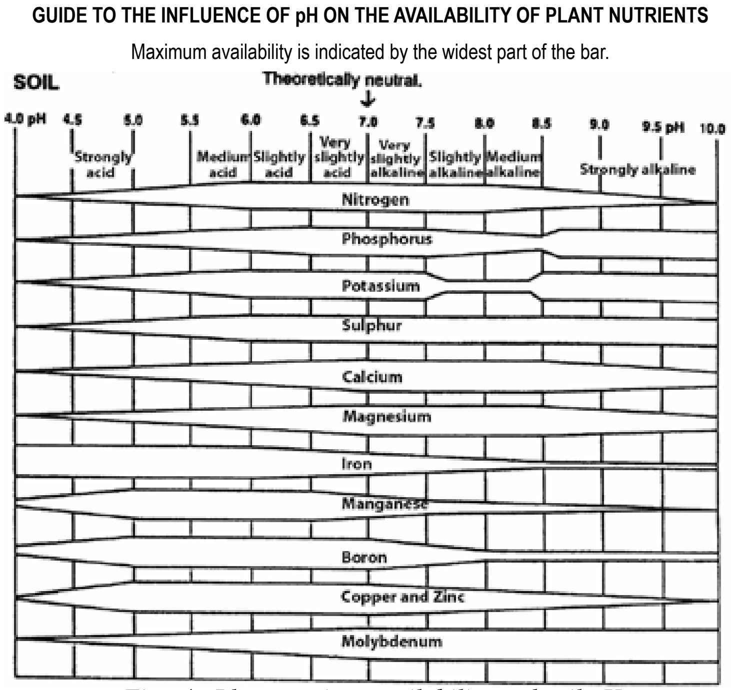


Fig. 4. Plant nutrient availability and soil pH

Another piece of evidence useful here is when you look at the conditions where very tall trees are produced in nature, such as the Sequoias of California or the giant Mountain Ash, *Eucalyptus regnans*, of southwest Tasmania. All these very tall trees are produced in areas where moisture-bearing mists come in regularly and deposit water directly on the leaves, as much as 100 metres up.

Explanation 3: Soil pH

Another factor is the pH of your soil. Fig. 4 shows how availability of different plant nutrients varies with the pH of the soil. You can see that no given acidity or alkalinity level is ideal for all nutrients - iron, for example, becomes much less available at high pH, while molybdenum shows the reverse.

By applying the needed trace elements directly to the leaves, this problem of nutrients being 'locked up' by the pH level of the soil may be avoided.

Explanation 4: Fertilizer from the Mulch

When I mentioned the mulch component of my technique, I said that it needs to be a thick, coarse mulch with sticks etc, resembling forest litter. What this implied was that it was a continually topped-up, permanently-present mulch, one that took a long time to be used up. Mulch materials which break down rapidly are useful, but they do not allow the establishment of mature-age mulch-converting organisms such as some fungi [Noel, 1995].

The organisms we think of as being active in composting processes are worms and bacteria. But in a mature-age composting process, one with significant input of woody material, fungi become very important.

There are many species and groups of fungi, and when a piece of a tree falls to the forest floor, wave after wave. of fungi go in, each attacking a different type of material. The first to go are the starches and sugars. When these are all gone, a new group attacks the cellulose or woody components. Finally, when the only thing left is the lignin component, a new group will come in and use that up.

This is a slow process - typically it may take 6 years to go through a complete cycle. And there are many more ramifications and interactions with other organisms, for example a beetle may live exclusively on one of the fungi, and a fungus may live preferentially on the droppings of that beetle. This may explain why it takes a several years for my technique to reach its full effect.

A further point here concerns the third leg of my technique. I suspect that the mulch provides most of the bulk nutrients needed for plant growth and fruit production. Why not make growth even better by adding fertilizer on the ground or mulch?

The reason is, that adding fertilizer to a fungal decomposition system actually depresses its growth and output. This has been shown both for wild forest stands and for cultivated trees, and is particularly marked for some nutrients such as phosphorus. Adding fertilizer to the system may actually reduce its efficiency, and it will certainly cost you more.

Explanation 5: A self-adjusting fertilizer programme?

Figure 5 shows a management calendar for different operations in a macadamia orchard [0'Hare, 1990]. It is a good example of what has been called the crop manipulation approach.

I have nothing against such an approach. I do not know whether it was developed in Queensland, but I regard the Queenslanders as the masters of this approach, and believe that they are owed a debt of gratitude for their work on it. The approach may be particularly useful when you want to distort normal crop behaviour, for example to move a banana crop out of the main crop period so as to get better prices.

This manipulation comes at a price, a price in labour, materials, and attention needed at different times of the year. With a crop like macadamias, the actual date of ripening of the nuts is not specially important. What I am suggesting is, that with my technique, a lot of the factors needed for good nut production are automatically built in, which can lead to big savings.

Explanation 6: Fertilizer from the Air

Finally we get back to the Bird's Message. It appears that the leaves of plants are actually subjected to a continual rain of nutrients, ones which are not especially obvious and which we tend not to take into account.

First there are gases such as nitrogen and sulphur oxides, produced both by natural decomposition and from human processes such burning fuels in power stations and vehicles. According to Frank Murray, a W A air pollution expert, there are enough of these gases in some human occupied areas to fill all a plant's needs for nitrogen and sulphur.

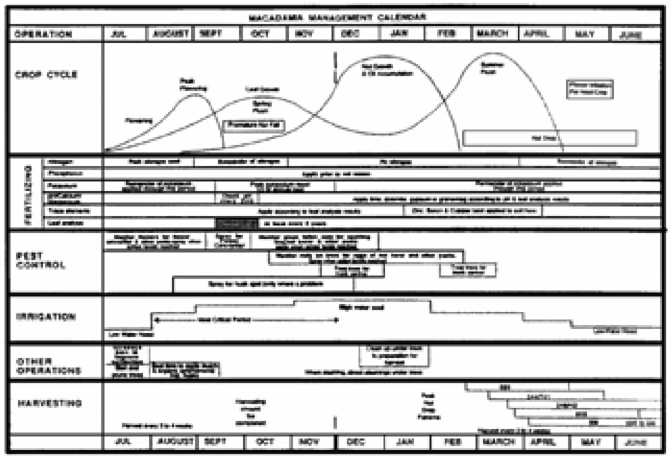


Fig. 5. Macadamia management calendar

He relates that in some coastal areas of Holland and Belgium, poor heathlands low in natural nutrients have been found to have changed themselves into more fertile grasslands purely from this pollution source, without any direct human intervention.

Then there is the impact of dust. Huge amounts of dust are continually moved around the planet by natural processes. A dust storm which hit Melbourne in 1983 was estimated by the Victorian State Soil Conservation Authority to have deposited more than 10,000 tonnes, that is over 100 kilograms of dust on each hectare of the city [Cummings, 1993]. Another dust storm in Queensland's Channel country [Amalfi, 1992] was said to have dumped more than 4 million tonnes of dust into the Pacific Ocean, equivalent to 60,000 trucks making one drop per hour for seven hours.

Volcanic eruptions, such as that at Mount Pinatubo in the Philippines, can also spread huge quantities of dust around the planet. The great Krakatau explosion of 1883 is believed to have dropped 20 cubic kilometres of dust, some 40 million tonnes, in the years following the explosion [Gebauer, 1992]. And from outside the Earth itself, there is as much as 300,000 tonnes of dust falling to the surface each year in the form of meteoroids [Bevan, 1993].

Because it is so fine, and has such a huge surface area, dust can be very active as a fertilizer --chemical reactions with solid materials take place almost entirely on their surfaces.

Lastly, let us have a look at an avocado leaf (Fig. 6). It is not an ideal leaf, but a real leaf, one with a history.

This is a leaf to make a good horticulturist blanch. The tip is burnt back. The leaf is showing deficiency symptoms. There are several holes caused by leaf-eating insects. And prominent on the leaf are several examples of the Bird's Message.

Look at these features again and see them as part of a complex and useful life. Of course the leaf has functioned in its main role of gathering light and turning it into energy and materials through synthesis, but it has done more. The tip burn is likely to be a natural mechanism to protect other leaves from excess sunlight, or a way of voiding excess salt. The 'deficiency symptoms' may just mean the leaf is approaching the end of its life and materials are being withdrawn to elsewhere in the plant.

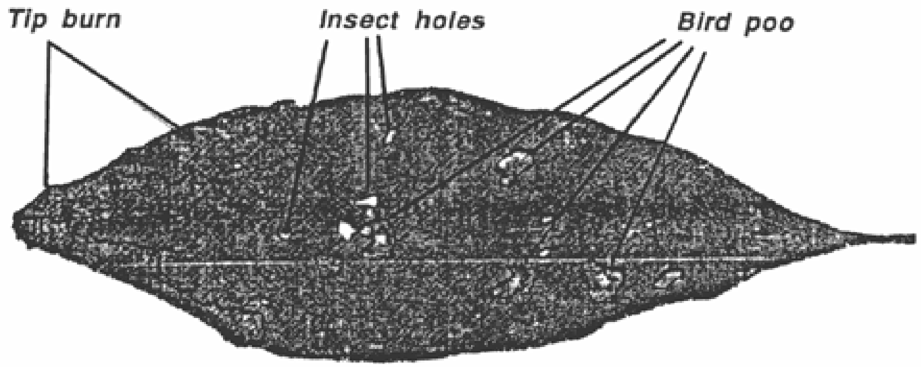


Fig. 6. A real avocado leaf

As for the Bird's Message, and even the droppings from the leaf-eating insect, are not these a perfect source of nutrition as the rains slowly dissolve them, and pour them over a cascade of lower leaves, to finally reach the ground at the drip line?

While we humans may not be able to impose a system as efficient as the bird's, we can follow the same principles. That is the basis of the technique described here.

Postscript

The paper as above was presented at ACOTANC-95, the Sixth Australasian Conference on Tree and Nut Crops, held at Lismore, New South Wales in September 1995. On the way there I called in at Tropical Fruit World near Coolangatta, to look at their spectacular range of unusual fruit and nut trees.

The first thing I saw rocked me back on my heels. There, piled around their avocado trees, were heaps of branches and logs from very heavy pruning, almost decapitation, of their trees (Fig. 7). When I asked why, Brian Monro told me that the practice had been found to improve the growth and yield of the trees. He picked up a log which had been lying against a tree for more than a year - it was very light, I would guess that more than half its mass had vanished.

Where had the mass gone? The possible answer was that it had been withdrawn from the log by fungal threads, and passed on to help nourish the trees. By coincidence, I had already been piling logs around my trees at home, with the idea of drying them for firewood, and had noticed that some had lost weight much more than their moisture content.

Since then, I have applied the log technique over all my plantings (Fig.8), and although it is still too early for quantitative results, visual indications have been very positive. This technique is definitely worth further trials in all sorts of situations - it could be the start of completely new approaches to tree crop nutrition.

Fig. 7. Avocado logs piled round trees at Tropical Fruit World

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Fig. 8. The ultimate controlled-release fertilizer?

BREEDING AND SELECTING NEW VARIETIES OF MACADAMIA

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Introduction

Macadamia is one of the least domesticated of nut tree crops presently grown on a commercial basis, thus there is a great deal of scope for improvement in varietal selection and breeding. The edible species, *Macadamia integrifolia* and *M. tetraphylla*, are indigenous to the coastal rainforests of northern New South Wales and southern Queensland, most of which has disappeared since European settlement. It is only now that a serious attempt is being made to preserve some of the remaining germplasm, in order to widen the present genetic base of commercial cultivars.

Although Macadamia was first observed by a botanist and explorer, Allan Cunningham in 1828, the earliest commercial planting in Australia was not until after 1880, at about the same time a small quantity of nuts were introduced into Hawaii. Selection of commercial varieties didn't begin until the nineteen thirties in Hawaii, the assessment criteria of that time (Story, 1955) is very similar to what we use today, apart from some extra characters which have since been added. We also weight the characters according to their importance and rank the selections through a computer (Bell et al, 1987).

The Macadamia Industry in Australia didn't really develop until the nineteen sixties, and the Industry was based on Hawaiian varieties. This proved to be a grave mistake because they were originally selected for a very different environment. Australian varieties selected in that era were later considered unsatisfactory for a number of reasons, but several have since been reassessed in regional varietal trials. One has performed much better than most of the Hawaiian varieties tested in the same trials.

The main difference between the Australian and Hawaiian selections from a breeding point of view is that there is more diversity in the Australian selections, while the earlier Hawaiian cultivars literally evolved from a handful of nuts brought to Hawaii in the last century from seed collected in the rainforest, from the one locality. A further introduction was made in the 1930's and in 1954, however by this time the Hawaiian breeding program was already well established. Early Australian selections on the other hand were made in a number of different localities and consequently have greater genetic diversity, thus more potential as parent trees in any breeding program.

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Most commercial food crops have been developed over hundreds of years and in grain crops the process has been going on for thousands of years. In Macadamia we have been selecting cultivars from open pollinated parent trees for only sixty years and doing controlled and semi-controlled crosses for less than twenty years. We are therefore in the fortunate position where we can still greatly improve existing yields, even without the aid of genetic engineering and modern technology.

If the maximum has already been achieved in yield, we can then go further by looking at precocity and high density (Chapman et al, 1984), dwarfing, disease and insect resistance. Macadamia grew naturally in what is now the most populated area of Australia, the east coast. If we wish to extend that area, which we must do if we are to continue to remain a force in world production, then the varieties will have to be more tolerant to temperature, rainfall, light and altitude.

Methods

It has taken us more than twenty years to develop the criteria which we now use in our present selecting and breeding program. Some of these methods could be of assistance to plant breeders in other crops.

Selection

What the Grower wants of course is the maximum amount of kernel per hectare with minimum production costs. However in order to achieve this, the Grower must accept that the kernel he has to sell, must also bring the best return to the Processor and most important of all, be readily accepted at retail outlets, look attractive on the shelf and sell at a competitive price. In vegetatively propagated tree crops there will always be room for improvement, so any new variety will in this sense be a compromise. In the field we visually assess up to 20 different field characters and eight kernel characters, then there are 6 entries of numerical data.

Rather than giving a detailed description of our present methods which have been previously recorded (Bell, 1995), perhaps it would be simplest to divide our assessment into positive and negative areas, what makes a good tree and what makes a bad tree. The ratings which we give these trees are weighted according to the importance of the particular characteristic which we are assessing. This is later fed into a computer and the selections ranked against those made in previous years. Industry standards change and selections which have been discarded in the past can be retrieved and reassessed.

Field Assessment

Selection in the field begins when the first trees in the progeny block start to flower, this will depend upon aspect and environment and size of trees when planted out. Let us assume that the first trees have started to flower.

Good Tree/Bad Tree

Year 1

Early Flowering. (Precocity).

Reject off types (poor growth habit etc).

Graphic from Growing Macadamias in Australia *by Paul O'Hare et al*

Year 2

Early Flowering and Crop. Kernel characteristics assessed on high yielding trees. Best ones given a code number and tested for quantitative nut in shell and kernel data.

Early Crop but Kernel Ratio not acceptable, tree still in juvenile stage. Test again Year 3. As trees get older, shell gets thinner and nuts usually smaller. Reject other trees which obviously have poor field qualities and could not carry heavy crop.

Year 3

Assess trees carrying heavy crop. Field and Kernel characteristics assessed on any new coded number selections and tested for quantitative kernel data. Yields and ratings checked on trees which were given coded numbers the previous year. Adjustments made where necessary to previous year assessments and the best of these trees with the highest yields again checked for quantitative kernel data.

Trees not flowering, or extended flowering and harvesting period. Trees carrying heavy crop, but appear sick. Check for bark canker, root problems, other diseases or scale or lack of foliage or chlorosis. Reassess Year 4.

Year 4

Assess crops and performance of all coded number trees. Record yield of best trees and' measurements of Canopy Base in m2 (Trochoulias, 1992) or Canopy Area (Bell, 1987). Plot on graph and measure against datum trees consisting of top performing varieties. Best performers are top worked onto mature seedling trees and are also propagated from cuttings. These are again assessed for performance against other elite cultivars and selections for at least four years. The best of these should then be tested for suitability for processing, roasting and shelf life, before being considered for regional varietal trials.

Reject all trees without coded numbers that have still not started to crop. Reject all those that have not produced good yields by Year 4. Don't assess good looking trees only carrying an average or light crop. Note them and eliminate following year if still not performing. A late starter has to have other major attributes in order to be given a code number. Reject trees carrying heavy crop but which have weak laterals badly spaced and/or foliage too dense or too sparse. Reject trees that have a marked alternate bearing pattern, this can only be observed over a number of years. A regular cropping pattern and drop period can only be assessed on mature trees.

Choice of Parents

At this stage little is known about heritability in *Macadamia*, we have no proof which characters are dominant, recessive, or under the control of a number of genes, we believe that most characters are multigenic and that only a few are dominant. In some breeding lines that we have crossed and selfed, we have found that the progeny are highly heterozygous and that there can be as much diversity in the selfed progeny as in the crosses.

In other breeding lines which have been open pollinated or crossed, the reverse is true and there is a marked degree of homozygosity in the progeny. We believe that until we know more about the basic genetics of *Macadamia*, it is best to stick to the tried and proved method in plant breeding of marrying best with best. Beyond the scope of general tree improvement, it is better to limit the characters in the parents which you hope to pass on to some of the progeny to no more two in number and preferably only one.

For example, let us assume you are looking for resistance to a particular disease. If both parent trees appear to have that desired characteristic, it is important that they should also have other good qualities, otherwise only a very small proportion of the progeny will be useful, even if they are resistant to the disease. It is an accepted fact that if you choose good parents, you will have a much higher percentage of worthwhile progeny in the first generation than would be possible if parents with bad field or kernel characteristics were chosen. Yield and Precocity both appear to be under polygenic control, therefore the chances of producing a higher percentage of progeny with similar characters should be increased (even if those characters are not dominant), if controlled crosses between similar selections are made. (Bell et al, 1987).

Dr Philip Ito, now retired and until recently in charge of the University of Hawaii Macadamia Breeding Program, was of the opinion that controlled crosses did not produce a higher level of useful progeny than poly crosses between a few selected parent trees planted in an isolated area, (personal communication). However it is our belief that this is due to the homozygosity of the parent trees and that if an injection of a new pollen source had been made earlier in the breeding program to some of the first named cultivars used as F parent trees, then the Hawaiian breeding program would have had a much higher percentage of useful progeny to select from.

Mutation Breeding

This is an area that we feel has potential, particularly in view to high density plantings of the future. Dwarf trees are often natural mutants or sports in other tree crops, or a combination between rootstock and scion which produces a dwarfing reaction in the scion. However mutants can also be produced artificially using mutagens which are usually short wave electromagnetic radiation, ionizing radiation, or chemicals.

We have tried irradiating var A 16 budwood with Gamma rays, however when budded onto rootstock, none of the trees showed any sign of abnormality. In retrospect, we believe that a higher dosage rate was required as the treatment was based on methods used for treating Avocado which has soft wood while the former has hard wood. We have also tried treating seed nuts with colchicine in view to producing polyploids. This had limited success, but not enough to be of statistical significance.

The third method which has produced the best results to date is to collect pollen used for crossing or selfing, and irradiate it with U.V. short wave light prior to performing controlled or semi controlled crosses or selfs. This appears to produce a greater degree of variability in the progeny and more mutants than one could expect in a normal progeny population.

We have also used pollen from what appear to be dwarf types and crossed them with other mutations or chimaeras. The progeny are only at nursery level at this stage, so it will be some years before they can be assessed.

Discussion

In assessing progeny lines in any vegetatively propagated tree crop, the first criterion must be Yield. How can that yield be achieved? We must first look at the tree.

A good tree should start flowering and set crop before 90% of the remaining progeny in the same block. Precocity also means early pay back, unfortunately some early precocious varieties do not continue to perform well when they mature, this is sometimes due to insufficient replacement of assimilates at an early age, or they simply burn themselves out. In this early assessment stage, a bad tree is one that starts to produce crop later than the average in the block.

A good tree must produce an exceptionally high yield which can be achieved in various ways on a regular basis, such as yield in relation to the size of the canopy or productive area per hectare. The tree must be vigorous (productivity is usually associated with vigour). In the case of nut crops, yield also can be related to thickness of shell or kernel recovery. Disease and insect resistance relates to yield and can be partially due to the physical properties of the nut or the husk. The tree must be tolerant to climatic change and an efficient converter of nutrients.

Nut Quality is the most important criterion apart from Yield and it is determined by a number of characters which are assessed on a qualitative and quantitative basis, but firstly the tree must be capable of producing the required Yield. Other factors which also relate indirectly to Yield include nuts which must husk cleanly, without too many 'twins' or split embryo nuts. They must be well shaped and show no tendency to pre-germinate or sign of weakness at the hilum or micropyle. The majority of the nuts must fall into the right size range and the drop pattern must be suitable for mechanical harvesting. The flowering must not be extended over too long a period.

The tree must be the right shape and have the right branch structure in order to avoid wind damage and carry heavy crop. Sufficient light must be able to penetrate into the inside of the canopy, so that the photosynthetic area is not limited to only the external portion of the total tree canopy. The ratio of leaves to linear branch structure also influences carbohydrate levels and nut production. The tree must produce crop on the inside of the tree close to the trunk, as well as close to the surface of the canopy.

One conclusion can be drawn from the regional varietal trials, in that no varieties perform in the same manner at different sites and under different climatic conditions. Also, fertilizer requirements based on Industry standards are not sufficient in a trial situation where selections with higher yield potential can burn themselves out through lack of nutrient, or at best are penalized by varieties which produce less crop and require less fertilizer. Optimum yields can only be achieved with the right variety in the right place and receiving the right treatment. This applies equally well in the selection process, if the progeny block doesn't receive the correct fertilizer treatment, any elite selections will not realize their full potential in producing crop.

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THE OLIVE IN TUNISIA - A MAJOR NATIONAL RESOURCE

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HISTORY

The Olive tree, *Olea europaea* L. s/sp *sativa*, belongs to the family Oleacea and the genus Olea, which includes some 30 species (Green & Kupicha,1979).

Chevalier (1948) and Emberger (1955) in Trigui (1987) considered *Olea chrysophylla* as probably the ancestor of *Olea europaea*.

In the Mediterranean region, olive extends right from East to West. At present the world olive resource is around 800 million trees, 98% of which are concentrated in the Mediterranean region.

The Mediterranean region produces around 98% of the world olive oil production, with an average of 1,400,000 tonnes per year.

In terms of table olives, world production has increased during recent years, and reached around 1,000,000 tonnes in 1993/94.

TUNISIA

Today in Tunisia olive trees cover 1,400,000 ha, which represents around third of the whole Tunisian agricultural area. About 57 million trees are grown. The table olive area is only 20,000 ha.

This large olive area has led to our country being called "Green Tunisia" because of the great expansion of olive trees all over the country, under various biotopes and climates, especially as regards rainfall. Our olive trees are grown right from moist regions with 1000 mm rainfall per year down to dry regions with below 200 mm per year.

The density of planting varies from 200 trees/ha in intensive cropping in the North to 50 in the Centre and only 17 in the South. Planting density used depends on rainfall.

In terms of potential of olive oil pressing, the around 1298 olive oil factories are mostly located in the Centre and the South. The factories have various different press systems; 817 use the classical system, 297 the press system, 37 the mix system and 147 the continuous system.

The table olive production is very low when compared to oil olive. The production of oil olive shows up and down fluctuations mainly due to some internal (variety and yield potential characteristics) and external conditions (biotope and cultural practices effect). This variation is greatly affected by the duration of dry periods.

At this time, olive oil export is an important component of the Tunisian external trade. This export represents an average of37% of the exported food products and 4% of the total export within the last decade (table).

Year	*84/85*	*85/86*	*86/87*	*87/88*	*88/89*	*89/90*	*90/91*	*91/92*	*92/93*	*93/94*
Table Olive production (t)	15000	13000	9650	11500	6250	13000	12223	15135	14100	12350
Oil olive production (1000 t)	631.3	646.7	575.7	580.6	316.4	670.9	825	1355	602.5	1050
Olive oil production (1000 t)	102	110	116	98	66	146	172	288	147	200
Olive oil export (1000 t)	76	46.3	44.2	57	52.2	47	50	158	96.5	122.6
Olive oil export (1000$)	74	51	67	79	82	86	121	287	156	175
Olive oil export % of total exports	4.1	2.97	3.81	3.7	3.44	2.93	3.46	7.81	3.9	4.64
Olive oil export, % of exported food products	41.07	31.88	31.64	29.77	28.15	30.55	33.33	55.34	41.27	44.41

OLIVE VARIETIES (see map)

The two main varieties of olive grown in Tunisia are:

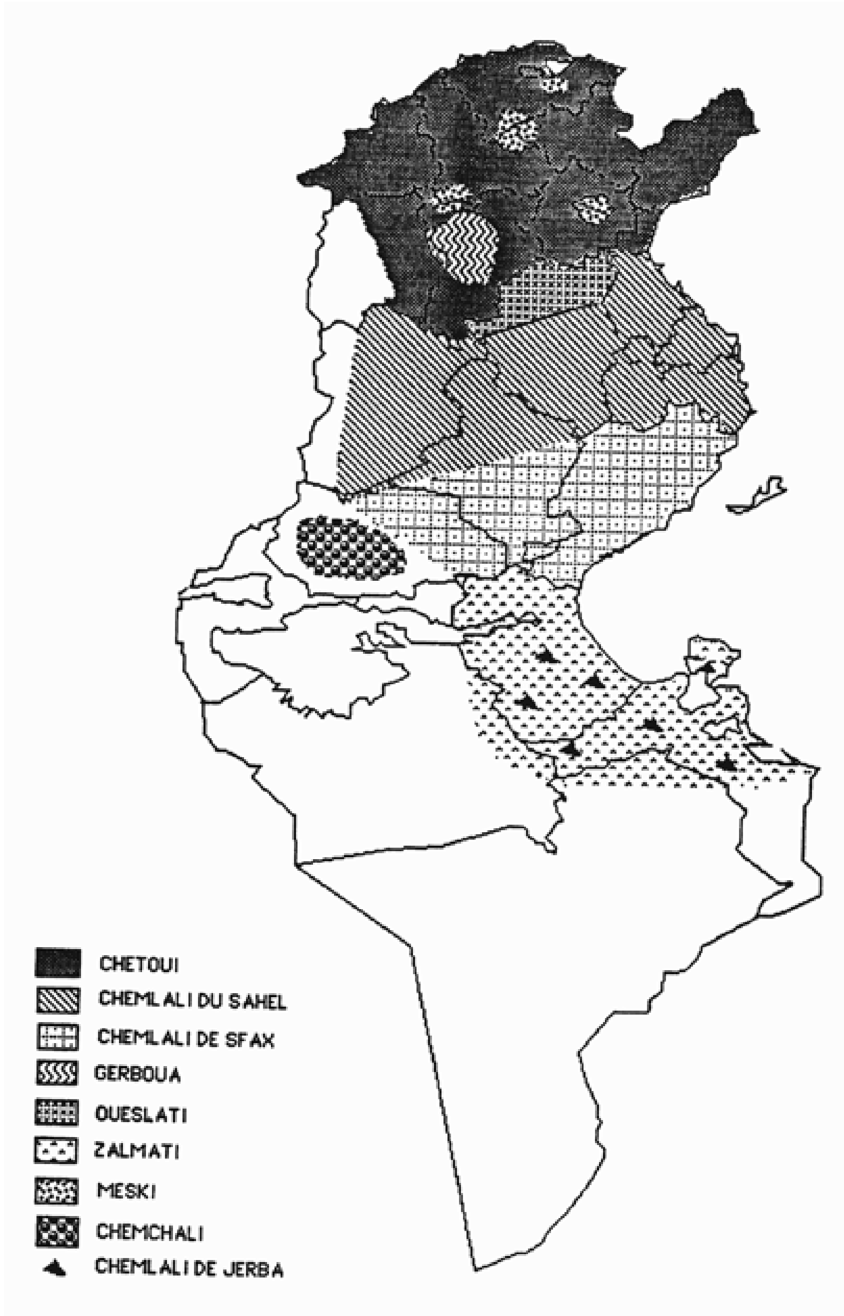
Chetoui. This variety is very common in the North. The stem and the leaves are short and show broom shape. The fruit with a variable size (around 2 g) is dissymetric and slightly arrowhead shaped.

The Chetoui variety is mainly used for olive oil production. The oil is fruity and doesn't solidify. Sometimes when the fruits are big, they are used as table olives.

The Chetoui variety is found in the following area: Khroumirie Mogods, Northern coast and North valley.

Chemlali. This variety is found in the olive orchards of Sfax and the Sahel. It is also grown in the warm coast area (from Korba to Gabes) and the lower steppe (Kairouan and Enfidaville). The tree is vigorous with a fallen shape, often very large. The fruit is small (around I g) and fusiform (Mehri et al,1995).

This variety is essentially grown for oil production. The olive oil produced is cloudy and



OLIVE VARIETIES DISTRIBUTION

slightly fruity, but of good quality. The rate of extracted oil is about 22%. This variety is planted in the warm areas - central and southern coast and the low plain.

Some other less important varieties are present, such as **Zalmati** in the southern East, **Chemchali** in the oasis of the southern West and **Oueslati** in the Western Centre.

Among table olive varieties, **Meski**, called 'Queen of the varieties' is the most frequent in Tunisia. The fruit is spherical with an excellent appearance, very fleshy and tastes very good. The mean weight of the fruit is around 4 g which represents 250 fruits/Kg. This variety is very famous in the local market and for export. The ratio pulp/core is very important. The core is easily removable. Harvesting for conservation begins in mid-September.

As well as **Meski** two other important varieties are grown and have shown an excellent adaptation to Tunisian conditions, especially in the newly planted olive orchards. These varieties, **Picholine** and **Manzanille**, come respectively from France and Spain.

Surveys conducted ten years ago have shown the occurrence of locally-originated varieties, and a great effort is being made to save these varieties and create a national collection.

CULTURAL PRACTICES

Olive trees are subject to a characteristic intermittent production. Usually a high production is followed by a great reduction the year after. This intermittent period is usually biannual and may be tri- or multiannual. This period depends on climatic conditions, mainly rainfall. All cultural practices may result only in reducing this intermittent production.

Pruning

Basically, it is conducted every other two years, which means after a good production year.

Fertilization

Nitrogen is the main fertilizer used. It is applied as ammonium nitrate (33%N) to productive trees at the rate of 3 Kg/tree. The application is conducted in two parts, in autumn and spring. It is also applied as a foliar application (urea, 46%N) in the young plantation.

Weeding

The major weed is couch grass (*Cynodon dactylon*). It is rather severe in dry areas. Roundup application is efficient but has to be followed by a good soil preparation.

Cultural methods

These methods depend on various factors; climatic conditions (rainfall distribution), soil quality (texture and depth), cropping, availability of water, variety characteristics ...

In the Sfax region, where rainfall is around 200 mm, olive trees cover about 400,000 ha and produce up to 50% of the national production. The soil is sandy and trees are planted at 24 m intervals (17 trees/ha). They are very productive. When conducted in good conditions, production can easily reach 600 to 700 Kg/tree. This involves a carefully-monitored dry farming regime based on a succession of cultural practices to weed and get rid of all adventitious plants.

To overcome water stress, farmers use 'direct flooding' through small water storage structures which allow the use of running water in olive orchards (El Amami, 1984, in Ben Rouina, 1994).

Main pests

Olive insects of economic importance in Tunisia are:

- The olive moth: *Prays oleae*
- The olive psyllid: *Euphyllura olivina*
- The olive fly: *Bactrocera oleae*
- The olive scolytidae

In the last few years, some less important pests have appeared: scales, pyralid moth, homoptera ...

The treatments are. conducted within a national control program through instructions coming from research and development institutions. The treatments are started whenever the economic threshold is reached.

CONCLUSION

Tunisian economy is mainly based on agriculture. The olive oil production is a very important factor involved in the development of the agriculture. Nevertheless, irregularities of production, high production costs and competition from grain oil are affecting the olive oil sector. Therefore, it's necessary to adopt some measures to overcome these constraints:

- improve cropping techniques in traditional orchards
- apply the new production techniques in new plantations
- allow the sector to use all the potentials through close linkage of research, development and extension
- encourage local consumption of olive through advertising programs, enhance export by prospecting new markets other than the European common market.

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THE LOQUAT: A FRUIT OF QUALITY

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The loquat, *Eriobotrya japonica* Lindl., is a close botanical relative of the apple and pear, all of which produce fruits known under the general name of pomes. Other well-known pome fruits are the apple, pear, quince, medlar and rose hips. All of these fruits are in the Pomoidae section of the Rosaceae, the rose family.

Among the common pome fruits, only the loquat is an evergreen tree. Other common names under which the loquat is sometimes known are mispel (German), nispero (Spanish), biwa (Japanese), pi pa (Chinese) Japanese medlar or rush orange (English).

While the loquat possibly is among the oldest of fruits cultivated by man in China, it was only in the late 17th century that the fruit became known to the Western world. Perhaps the loquat was grown as a fruit tree in China more than 2000 years ago. The Japanese apparently imported the species from China more than 1000 years ago to exploit the fruit and improve the quality by careful selection of hundreds of cultivars.

Japan remains at present the world's largest producer and user of loquats. Commercial production today is found mostly in Japan, China, Spain, Italy, Brazil, Israel, Australia, Algeria, United States (California) and in some areas at higher elevations in several tropical countries of Central and South America.

The Western world learned of the loquat when, in 1712, Kampfer recorded the species growing in Japan and known under the former name *Mespilus japonica* Thunb. The species was formally described by Lindley in 1882 under the revised name *Eriobotrya japonica*. It was imported into France in 1784 and shortly thereafter arrived in England at Kew Garden under Sir Joseph Banks.

The Loquat Comes to California

The loquat probably came to California after commercial exchanges were initiated with Japan in the early l800s. Several nursery catalogues from the San Francisco and Sacramento areas list the loquat about 1870. Curiously, this is approximately the same time when the avocado and the cherimoya were first introduced into southern California.

Shortly after 1870, the loquat was planted in several of the warmer areas in southern California, where it was found best adapted to the areas of mild winters and with cool ocean exposures. During 1880-1890, several commercial orchards of 2-8 hectares or more began to produce fruit particularly for the Los Angeles market. A major grower was C.P. Taft of Orange County who propagated and sold many loquat trees and selected a number of outstanding cultivars from among his seedlings. Many of Taft's selections were distributed widely in California and sent to others countries. Some of the cultivars are still valued and available from nurseries today. Among these are 'Early Red', 'Premier', 'Advance', 'Champagne' and 'Gold Nugget', all of which originated in Orange County.

The cultivar 'Thales' was introduced by the Berger Nursery in San Francisco and brought to Placentia in 1880. The cultivars 'Thales' and 'Gold Nugget' are similar in many respects; hence both cultivars possibly have been inadvertently introduced into many orchards under either name. The cultivar 'Tanaka' is a well-known cultivar which originated in Japan and was introduced into California by the U.S. Department of Agriculture, probably before 1880. It is among the largest of loquat fruits, egg-shaped and orange in colour.

Climate Effects

While the loquat tree can be grown as an ornamental in many of the milder areas of central and northern California, it is only in the coastal areas of southern California from Santa Barbara to San Diego counties that the fruit is produced regularly in quantity and of sufficiently good quality in most seasons to make commercial production feasible.

Several factors have possibly limited the development and exploitation of the loquat in California as a substantial commercial industry. The tree is somewhat frost-tender, but will withstand temperatures of -4 to -7°C. As the tree produces flowers in the fall from October to February, the young fruits can be affected by low winter temperatures or late spring frosts which kill the embryos in the seed, thus affecting the fleshy fruit tissue. This cold damage results in a condition resembling sunburn. The fruit becomes sunburned, withered and desiccated.

The very soft and fragile nature of the flesh with its comparatively thin skin which bruises easily makes the product difficult to handle if harvested at the optimum and appropriate time for maximum fruit quality. Fruit harvested somewhat immature does not attain good quality. Mature or overripe loquat fruits do not drop from the tree as is common among most other fruits. The old fruits merely decay or dry in place, hence must be removed mechanically from the tree.

The comparative difficulty of handling the fragile fruit in addition to the relatively short shelf life and storage ability plus the need for several additional hand operations to produce fruit of high quality has prevented extensive exploitation of the loquat as a major commercial fruit in California.

A factor in favour of the loquat is its early-season maturity and availability when few or no other local fruits are in the market. The fruit is offered in limited amounts in specialty fruit stores and through Farmers' Markets in many communities throughout California. Production for these outlets results from small plantings generally of only a few trees. Small shipments of loquat fruits to eastern markets have been reported.

Growth Habits and Rootstocks

The evergreen loquat tree, resistant to heat and drought, attains a height of 7 -10 m with an upright growth habit. The branches are not easily broken unless heavily laden with fruit which is a condition frequently developed. The rather large elliptical-Ianceolate leaves are borne in whorls at the terminals of current season's shoot growth. The leaves, six to ten inches long, are often somewhat toothed, deep green and smooth above, but with a deep woolly tan cover beneath.

The inflorescences are borne as branched panicles at the tips of current shoot growth. Each panicle produces about 100 flowers of which 40 to 60 will attain full development. The inflorescences together with the stems near the young shoot terminals are covered with a woolly surface layer, a prominent characteristic of the species, from which the name Eriobotrya [erios=wool (Gr.), botrys=c1uster; hence woolly cluster] was derived. The rather inconspicuous white but fragrant flowers generally are produced in the fall when no other common species are in bloom.

The Fruit: Description and Uses

The fruit is pear-shaped to round, one to three inches long with a skin similar in texture to a plum. The fruit structure is similar to that of the apple, namely a pome, with the soft fleshy portion consisting of a swollen receptacle which encircles the true botanical fruit represented by the core. The end of the fruit is in the form of a small open cup in which are found the remnants of the calyx as small, imbricate, acute teeth.

The fruit has five locules, each of which can produce two seeds. Usually only three to five seeds develop per fruit. The large, brown, smooth seed, up to three-quarters of an inch long and flattened on one side, contains prussic acid in common with the seed of other rosaceous fruits such as peach, almond and apple. Ingestion of the seed is reported to be toxic for some animals and for humans.

The loquat fruit becomes mature about 10 days following the appearance of the pink or reddish colour in the skin. The several fruits in a given cluster develop rather uniformly hence the entire cluster can be removed at harvest. Each fruit should be cut with a small portion of fruit stalk attached. Fruits should not be pulled from the cluster. Where birds and sunburn may be a problem, the use of ventilated paper bags just prior to harvest will retain or possibly improve fruit quality and reduce fruit loss.

Excessive fruit-set in the individual inflorescence can sometimes result in the formation of a tight fruit cluster. This will cause adjacent fruits to rub on each other within the restricted space. Thinning of fruits can be done within the clusters by removal of alternate fruits when the fruits are very small about one- fourth their ultimate size. The remaining fruits will increase in size and improve in quality.

Under most conditions the loquat tends to develop an alternate-bearing pattern, setting a heavy crop of small fruits one year followed by a light crop of somewhat larger fruit crop the following year. Cluster thinning in heavy production years can modify the alternate-bearing pattern. Cluster thinning can be accomplished by removing one-half to three-quarters of entire flowering shoot terminals; clip the entire inflorescence at the stage when the flowers are first visible. Additional increase in size of the remaining fruit then can be attained by fruit thinning.

Eriobotrya japonica (from Indische Vruchte*, by J.J. Ochse)*

The loquat fruit when carefully grown and packed makes an appealing fresh-fruit product. Single-layered trays or divided trays similar to an egg carton with a single fruit in each section provide the maximum protection for the tender fruit which should be handled "as carefully as an egg." Often the fruit is sold as an intact fruit cluster. Its value as a dessert fruit of high quality is appreciated by many. It is eaten as a fresh fruit or as an ingredient in fresh fruit salads and as loquat ambrosia. It can be peeled, quartered and dried when it becomes like a dried date. The use of firm, slightly immature fruits in loquat pies provides a treat suggesting a fine cherry pie.

Perhaps the most common use of the fruit is as a jelly or jam. It can be preserved as a canned product or as a compote in syrup especially when the yellow-fleshed fruits are used. The seeds sometimes impart a bitter flavour hence are removed in such preparations. Poaching in sugar provides a product of fine flavour. Wines can be made from the fruit.

Other culinary preparations which have been tried are loquat chutney, pork roast with loquat, gelatin cup, carrots and loquat, loquat lazy ice cream, spring loquat sauce and loquat with cottage cheese. The loquat is comparable to the apple in many aspects with a high sugar, acid and pectin content.

Clonal vs. Seed Propagation

Many loquat trees grown from seed will produce acceptable fruit from the dooryard garden tree. High-quality fruit required for commercial production or desired by the more sophisticated grower requires the use of grafted or budded nursery trees of selected high-quality cultivars.

The use of loquat seedling rootstock usually results in a comparatively large tree with a high canopy reaching 20 to 25 or more feet. These tall trees require training in the early years and frequent pruning, usually with the objective of a low head to facilitate fruit thinning and harvest and other tree management operations. Many nurseries provide standard loquat cultivars grown on quince (Cydonia japonica) rootstock which produces a dwarfed tree of early-bearing character. The dwarfed tree exhibits adequate fruit production with the advantage of easy handling in the orchard or the door-yard collection. Quince stock easily grown from cuttings is used commonly as rootstock for loquat cultivars in Europe and Japan and other areas. Cleft grafting or shield budding are commonly utilized for loquat propagation. The objective in pruning older trees is to obtain a low, flat-headed tree to facilitate fruit-thinning and harvesting operations.

Diseases and Other Problems

The loquat tree is relatively free of major pests and diseases and other problems common to most orchard species. A major concern is the development of pear or fire blight caused by *Erwinia amylovora* which can cause dieback of individual shoot tips or death of the entire tree in severe cases. Control of fire blight can be attained by the use of preventive fungicides or bactericides and by removal of affected branches. Blighted branches are pruned out by cutting below the infected sections, taking care to sterilize the pruning instruments and to dispose of the affected tissues preferably by burning. Occasionally infestations of black scale may appear.

The problem of birds feeding on mature fruits sometimes is of concern particularly when no other mature fruits are available in the neighbourhood in early spring. Bird attack is best handled by use of paper bags to cover the individual fruit clusters, a control especially practicable on dooryard trees.

Cultivars

Selected cultivars of loquat are generally classified into two groups according to the basic flesh colour, orange-fleshed or white-fleshed. Among the orange-fleshed fruits, ‘Early Red’, selected by Taft in 1909, still remains a good cultivar. It is a small pear-shaped fruit with an apricot flavour and of very early maturity.

‘Gold Nugget’ or ‘Thales’, orange-fleshed and probably identical, is slightly larger and later in maturity. ‘Tanaka’ is among the largest of fruits and keeps very well. The cultivar ‘Mogi’ produces a small elliptical fruit of good quality, but it bruises easily. A recent California introduction is the cultivar ‘Big Jim’, a large fruit with orange flesh and well adapted to more arid conditions.

White-fleshed cultivars grown successfully in California include ‘Advance’, another of Taft’s selections with a medium-size fruit. The cultivar ‘Champagne’, an oval-shaped fruit with a distinctive, attractive flavour, was also selected by Taft. Another more recent California introduction is the ‘Benlehr’, a large-fruit type from San Diego County.

Without doubt there are many older loquat cultivars which persist in dooryard trees that are unknown to the public and are unidentified, yet are valuable to horticulture in general.

A recent survey of some prominent nurseries specializing in subtropical fruits indicates that only a few recognized loquat cultivars are currently offered to the public. Among these are ‘Gold Nugget’, ‘Champagne’, ‘Advance’, ‘Benlehr’, ‘Big Jim’, ‘Macbeth’ and ‘Tanaka’.

A number of cultivars from abroad have been imported and established by some enthusiasts but evaluation of the quality and performances of these clones is not yet available. Among the better loquats introduced into California from New Zealand are ‘Strawberry’ and ‘Mrs. Cooksey’.

Among current Italian cultivars introduced in recent years are ‘Vaniglia Precoce’, ‘Conigliaro Bianco’, ‘Carasi’, ‘Precoce di Palermo’, ‘Argelino’, ‘Nespolo Rosso di Trabia’ and ‘Grosso Lungo di Palermo’. Other cultivars imported from Florida are ‘Wolfe’, ‘Oliver’ and ‘Sherry’. The ‘Magduhl’ and ‘Argeli’ from Spain (perhaps asynonym for ‘Argelino’) also have been reported as established in California.

Thus many of the more attractive selections from abroad, currently under test in California, should provide interesting information for the loquat enthusiast or the commercial grower in future years.

[Dr. C.A. (Art) Schroeder, botany professor emeritus, UCLA, is currently investigating the role of static electricity in pollination.

Based on an article in the California Rare Fruit Growers magazine *Fruit Gardener*, July August 1995]

NEW DISCOVERY IN TURKEY: NUTS MAY BE THE ORIGINAL STAPLE FOOD

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According to recent archeological findings in the highlands of eastern Turkey, nuts, not cereal, may have been the original food in ancient village life.

Even the most cursory review of the anthropological literature reveals that wild edible nuts were exploited. How far back into prehistory such exploitation patterns go is not completely clear. What is clear, is that subsequent to the end of the last Ice Age, humans in many parts of the world began to experiment for the first time with new subsistence patterns centred on the intensive exploitation of edible nuts and selected plant species such as cereal grasses.

In the process, they also developed technologies for processing these new dietary staples. In the Near East this economic change is called the “Broad Spectrum Revolution”: in North America it is the hallmark of the prehistoric period called the Archaic.

In some areas, such as California, sedentary village societies based solely on the intensive exploitation of wild nut species (in this case, acorns) persisted into the colonial period. However, in other areas such as the Near East and American Midwest, economies based on the exploitation of wild nuts soon gave way to new economies based on cereal agriculture.

Thus, contrary to earlier thinking, it has become increasingly clear over the past half century that settled village life, often dependent on wild nut-based economies, preceded the beginnings of agriculture. Interestingly, there is also a growing body of evidence that such life ways did not just precede agriculture, but actually fostered its invention.

The exploitation of edible nuts, however, did not cease with the shift to agriculture. Pistachios and almonds were domesticated and became integral components of subsistence economies based on food production. Let’s examine the possible dietary role of edible nuts in the development of both settled village life and agriculture. Several issues in the domestication of edible nuts still require substantial research to resolve.

Edible nuts and the beginnings of settled village life

For people who subsist by the hunting and gathering of wild foods, a sedentary way of life with its smaller territories poses significant risks over more nomadic lifestyles. Chief among these is the risk of local resource depletion. This risk can be partially mitigated by the development of storage technologies. These make possible the carry-over of seasonal surpluses into the rest of the year and thus permit the successful exploitation of high-yielding plant species such as nuts and cereal grasses.

Some local resource depletion, however, is virtually inevitable with increased sedentism. Energetically, this is handled by concentrating on the exploitation of those resources having the highest food quality and predictability. In environments that harbour them, edible nuts and cereal grasses, with their high nutritional value, are typically the highest quality plant food resources available. They are also capable of being efficiently stored. Thus, the correlation between the appearance of the earliest settled village societies and the beginning of the intensive exploitation of edible nuts was not fortuitous.

The precise relationship, however, between the beginning of settled village life and the intensive exploitation of nuts and grasses is still hotly debated. Some researchers view these resources as a draw that.pulled people into sedentary life-ways because they make such life-ways possible. This view largely begs several important questions. Of these, the most critical is: why would people choose to exploit these resources in view of the fact that they require considerably more labour than alternative resources for them to be rendered edible?

Others, on the other hand, view sedentism as the evolutionary logical outcome of population pressure. In this view, the energetic costs of territorial defence rise with population pressure and territorial size. Thus, sedentism is to be expected whenever suitable resources occur and the energetic cost of defending a large territory (with its wider array of less labour

Photo by Dr. Rosenburg of almonds and pistachios believed to be 7,000-10,000 years old intensive food resources) begins to outweigh the cost utilizing more labour intensive resources in the context of smaller territories. This view proposes that people were forced to settle down and, when they did, they centred their now smaller territories on the highest quality and most predictable resource available: that resource is edible nuts in every context where they are found in sufficient density.

Edible nut exploitation and the beginnings of settled village life

Sedentary human life-ways have been well documented to allow for higher birthrates than more nomadic ones. Thus, settled village life, once instituted, intensified the population pressure that likely produced sedentary life-ways. Ultimately, the dietary stress resulting from the high demographic growth of sedentary human populations outstripped the capacity of the natural environment to feed them and prompted the still more labour intensive economic innovations we lump together under the term 'agriculture.' In essence, agriculture is thus simply a higher level set of risk management techniques practiced by already sedentary populations--ones that provide greater control (at the expense of greater labour) over food resources availability than did the hunting and gathering of wild foods.

Beyond making sedentism possible, the role of edible nut exploitation in the beginnings of agriculture is still not completely clear. The conventional view has been that economic systems centred on edible nut exploitation are tangential evolutionary trajectories, with agriculture growing only out of those centred on the exploitation of cereal grasses from the very beginning. I, on the other hand, have argued otherwise - that the exploitation of nuts typically precedes that of cereal grasses, with production of the latter beginning simply as a supplementary behavioural subsystem that over time overshadows the original system in economic importance.

Nuts are the fruit of relatively long-lived trees. Annual fluctuations in yield aside, this makes their yearly availability highly predictable and an ideal resource to centre a sedentary hunting-gathering system on. Also, the tools required to process nuts (and grasses) are heavy, cumbersome and require considerable effort to produce, making them ill-suited to a nomadic life-way.

Trees, however, take a long time to become productive and are thus not very amenable to manipulation, particularly in response to short term needs. Hence, the focus on annuals such as cereal grasses as opposed to the dietary staple- edible nuts-in the earliest attempts at food production. Over time, as populations continue to grow, the production of supplementary annuals comes to dominate the subsistence economy.

This is evident in the American Midwest (hickory nuts vs. chenopods, amaranths, sunflower and later maize) and the American Basin (pine nuts vs. various grasses). Until now, evidence for it also having been the case in the Near East (almond, pistachio, acorns vs. wheat, barley and pulses) has been generally lacking. However, recent discoveries in the highlands of eastern Turkey indicate the existence there already 10,000 years ago of fully settled village societies with economies dependent on the intensive exploitation of almonds and pistachios. This is several hundred years before the earliest evidence for cereal and pulse agriculture in that area.

Areas for future research

Whether the highland pattern in the Near East will be confirmed by discoveries in lowland areas such as the Jordan Valley (another centre of early settled village life in the Near East) remains to be determined by future research and the use of techniques designed to facilitate the recovery of plant remains. Expectations are divided.

The discoveries in eastern Turkey raise several interesting questions that have yet to be addressed by anthropological research. For example, by 7,000 years ago, almonds and pistachios were domesticated in the Near East, while acorns, another major product of the native semi-humid forests in that area, never were. One possibility is that this is a result of differences between almond, pistachios and acorns in the area of fat/protein vs. carbohydrate content or some other aspect of food quality, making one more desirable than the other. Another is that acorns are simply not as susceptible to the type of breeding practices that first produced arboricultural domesticates.

In a related vein, both acorns and wild almonds contain some toxins (tannin and hydrocyanide), though the precise toxicity of wild almonds remains to be determined. While these toxins have been bred out of domestic almonds, some processing must have been required to remove these toxins and render wild almonds edible prior to the time of their domestication. What these techniques were is still not clear, primarily because experiments to detoxify wild almonds have never been carried out. The evidence from Hallan Cemi indicates that its inhabitants were roasting almonds. They were also pounding/ grinding as well as leaching some foodstuffs as well. Whether almonds were so treated and if so, how this or roasting improved their edibility, is not clear.

The Near East is the natural habitat zone of several of the most economically important cereal and nut domesticates. Until recently, research has focused primarily on the role of cereals in the origins of settled village life and the processes whereby they were domesticated. Edible nuts, though known to be widely consumed over much of the prehistoric and historic world were thought to play tangential roles to these processes in the Near East, the site of the earliest attempts at settled village life and agricultural practices. Recent research in the Near East has begun to undermine that assumption, but many important questions remain.

[Based on Dr. Rosenburg's presentation about his discovery in Turkey, reported in the International Nut Council's magazine *The Cracker*, January 1996].

THE CHINESE JUJUBE, ZIZYPHUS JUJUBA

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Chinese Jujubes, also called Chinese Dates (members of several species of *Zizyphus*), originated in China 12 to 14 million years ago, or possibly longer.

The trees grew quite well under growing conditions different from those of today. As climatic conditions started to change, over a period of time many plants all over China started disappearing, however the Chinese Jujube survived and adjusted to the new climatic conditions without any problem.

Today in China, there are 749 varieties of jujube, with 75% of these in the northern region and 25% in the southern region. There are two groups of Chinese jujube.

Group 1: Sour Dates (*Zizyphus jujuba* var. *spinosa*. Hu.) An ancient type of date known as 'Spike' in former times. Mainly used as rootstock, for medicinal use, or as fodder in animal husbandry. There are mutations of sour dates, such as Tain Lui Lui, Ma.

Group 2: Cultivated dates (*Zizyphus jujuba* var *enermis*), the modern type date. All cultivars grown in China today originated from this variety. Most cultivars and species grown today are up to 3000 years old or more, for example Xiang, Zao, Jin Si, Xao, Wuhe, Xiao etc.

The cultivated dates are divided into two types, **Northern dates** and **Southern dates**. The northern dates tolerate very low temperatures eg -30°C, highly alkaline soil (pH 8.5 - 9.0), and droughts, while southern dates tolerate very high temperatures and humidity and low acidity soil.

The Chinese jujube has many uses such as dried dates, crispy dates, processed or smoked dates, drinks, paste, vinegar, alcohol, leaves used to make tea, herbal medicines or as fodder for animals. Flowers are a good source of nectar for producing high quality honey. The wood is good for firewood, furniture, sculpture etc.

Chinese Jujube is an easy tree to grow and varieties can be found to fit any set of conditions. They are drought resistant, wind resistant, tolerant of waterlogging, high alkalinity and salinity. They can endure temperatures from 45°C to -35°C. They will grow in a variety of soils and to an elevation of 1800 m.

The trees are quite attractive with glossy leaves, even more spectacular with flowers and fruit. They range from 3 m to 25 m in height, with growth ranging from slow to vigorous. Most grow upright and become weeping with heavy crops of fruit. Some spread and some are ornamental. All are deciduous. Fruits are of a great variety of shapes, sizes and colours. The largest fruit in China is a 90 g southern date.

The times of growth, flowering and fruit maturity are largely temperature dependent and vary accordingly in different regions. Chinese jujube has some chilling requirement to put plants into dormancy. Without dormancy the timing of growth, flowering and fruiting are affected, producing poor and irregular results. Good consistent results depend on the temperature of each region so it is important to select the right cultivars for a particular region. For example, south of Perth Northern Dates are recommended, while north of Perth Southern Dates are recommended.

The flowering period is usually long. Chinese jujubes are self pollinating. The success of good pollination depends on the level of temperature and humidity. Each cultivar has its own range of ideal conditions for humidity and temperature; some of these ranges are narrow, others are broad. The release of pollen for some cultivars is very quick, others slow.

There are two basic flowering types: morning and evening. These are only classification types and have nothing to do with pollination. Yields are improved up to 19% by using plants of the same flowering group. Bees help pollination (up to 30% improvement in yield) and use of the ancient technique of cincturing can improve yield by 110%. Yields range from 50 to 300 kg per tree (25 year old trees).

Variety	Fruit/yr/tree (kg)
Ji Dan	50
Lang	50
Li	65
Jun	150
Yufu Shui	200
Lin Tong Bai	300

The jujube. Zizyphus jujuba

Chinese Jujubes in Australia are essentially free of diseases. There is a serious disease of jujubes, called 'witch's broom' which is a problem in China and Korea. The Koreans have been trying to breed cultivars resistant to this disease. The Koreans are the only people who have investigated the genetics of jujubes. I believe that it is very important that anyone wishing to import jujube trees insists on virus-free material. Fruit flies can attack the fruit.

I have collected 48 of the best varieties of Jujube. I have a selection of northern and southern dates and a selection of Russian cultivars. I have had considerable experience at bringing material in through quarantine. At present, the characteristics of the varieties are unknown. It is necessary just to plant as many different kinds as can be obtained and see how they perform in different environments.

The market for Chinese Jujubes has made tremendous growth and contains great potential. At present the annual yield is only half a million tonnes, only supplying half to two thirds of the total domestic market in China. In the international market, the jujube is at the development stage and has yet to become a commodity.

China exports to Malaysia, where jujube is regarded as a necessary tonic in Winter. The Russians regard jujube as a superior and precious food. The Japanese favour all kinds of medicinal foods prepared mainly from jujube fruits. In the USA, Canada, Singapore, New Zealand and south east Asian countries as well as Taiwan, Hong Kong, and Macao, the demand for jujube is very large and people there regard jujube as a health protection and cosmetological food and eat them in considerable quantities. People use jujube as a traditional gift for their relatives and good friends on holidays.

All these factors increase the demand for jujube year by year on the international market. The dried products are easy to store, pack and transport. There are traditional local special products for export in China which are very famous all over the world.

Nowadays the export price per tonne is around $1600 US. The selling price of jujube on the international market is rising dramatically and surpasses the value of other dried and fresh fruits. For example the selling price of the Jin Si Xiao per tonne on the international market is equivalent to ten tonnes of walnuts or 30 tonnes of apples. In Australia our local market has yet to be tapped. The potential is there so long as good cultivars are grown.

Dried Chinese Dates are by far the best for the market because they can be stored for long periods and fruit can be supplied all year round. Jujube is a fruit that is very good for anybody including children. You can eat as much as you want of the dried fruit, you never get tired of them. Children just love the fruit because they are nice and sweet.

At the moment, it is very difficult to buy jujube trees in Australia. Some trees found in nurseries may be seedlings of the thorny, suckering, wild type. Additionally, there is a problem with the names of older introductions. Many are incorrect. I believe it is important to reestablish the correct names and descriptions. I hope to be able to supply a limited amount of plants in the future.

EDIBLE INDIGENOUS NUTS IN PAPUA NEW GUINEA: - THEIR POTENTIAL FOR COMMERCIAL DEVELOPMENT

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There are over forty indigenous plant species with an edible kernel in Papua New Guinea (PNG) but only eleven are classed as being important in village agriculture.

Of these, six are seen as having potential for commercial development. These are cut nut or pao (*Barringtonia procera*), galip (*Canarium indicum*), karuka (*Pandanus julianettii*), okari (*Terminalia kaernbachii*), Polynesian chestnut or aila, (*lnocarpus fagifer*), and sea almond, talis or Java almond (*Terminalia catappa*). All six species, particularly galip, karuka and okari, are marketed locally and are sometimes sent to more distant markets within PNG.

The main criterion for selecting these species as having potential for commercial development was their acceptability by people from outside the area where they are traditionally grown. Commercial ventures are currently being established for roast galip nut in West New Britain and for fresh okari nuts from the Managalas Plateau in Northern Province.

People live and practise agriculture over a wide range of environments in PNG. These cover: an altitude range from sea level to 2800m; a rainfall range from 1000 to 8000mm/year; climates with no dry months to those with an average of seven dry months; and land forms which include raised coral reefs, coastal plains, mountains and hills, colluvial fans and highland valleys.

Nut-bearing species and other tree crops are grown in all inhabited environments, but there are three in which they are particularly important for villagers' food supply.

The first of these is the high altitude zone (1800 to 2400 m) and the very high altitude zone (2400 to 3000 m) where karuka and wild karuka nuts are very important. Villagers living in these zones commonly trade karuka nuts with those living in the main highland valleys between 1400 and 1800 m.

The second important environment is the highland fringe (600 to 1200 m) on the New Guinea mainland. Here, the staple foods include combinations of sago, bananas and root crops. These are supplemented by marita pandanus fruit (*Pandanus conoideus*), breadfruit seed, tulip (*Gnetum gnemon*) leaves and seed, and sometimes castanopsis nuts (*Castanopsis acuminatissima*) and sis nuts (*Pangium edule*).

The third environment in which tree crops, including nut-bearing species, are particularly important is that on small islands. These include those off the north coasts of New Guinea and New Britain, those east of New Ireland, the Mussau Islands and the islands of Milne Bay Province.

While still an important component of the diet, there has been a steady decline in the significance of fruit and nut tree crops with an increase in arable agriculture in these islands. The major change in agricultural production has been the incorporation of sweet potato and cassava into agricultural systems.

Cut nut (*Barringtonia procera*)

This species has a very limited distribution within PNG. It is commonly grown and eaten on Bougainville Island, New Ireland, the Gazelle Peninsular of New Britain and on Karkar Island. It has been suggested that this limited distribution is the result of it being a comparatively recent introduction that originated from the Solomon Islands.

Cut nut is grown from sea level to 500 m altitude, near the coast and in inland locations. The rainfall range is 2000 to over 4000 mm/year. Production appears to be intermittent throughout the year and non-seasonal. In the Bismarck Archipelago cut nut is eaten by outsiders, including expatriates. This acceptance suggests that it has good prospects for commercial development.

Galip (*Canarium indicum*)

Galip is widely distributed in lowland areas on the northern side of New Guinea and in all island groups. Galip grows near villages, in woody regrowth after cultivation and in mature forest. Trees are usually dispersed and not grown in groves. Self-sown seedlings are protected and trees are planted, often being selected for desirable characteristics.

Galip grows from sea level to 700 m altitude and in locations with a wide range in rainfall from 2000 to 6000 mm/year. It occurs on both well drained and poorly drained sites in forest locations but is uncommon in grasslands.

Production is typically seasonal and generally lasts for about three months. The production pattern is independent of the rainfall pattern but the commencement of production varies with latitude, which suggests that it is determined largely by day length. Anecdotal evidence suggests that there is considerable genetic variation within the species in PNG.

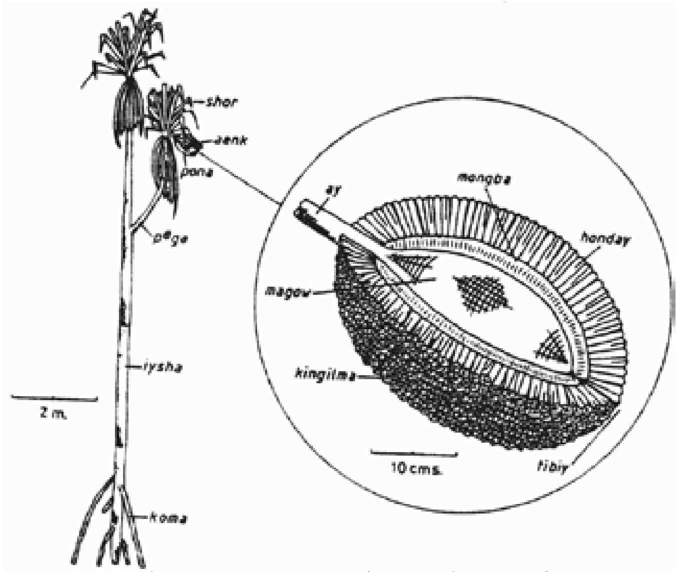
Galip is popular among outsiders, including expatriates, and the prospects for its commercial development are considered to be excellent.

Canarium indicum (From Ochse, 'Indische Vruchte)

Karuka (*Pandanus julianettii*)

Karuka is very widely planted in a narrow altitudinal band in the highlands in the central cordillera of New Guinea and on the Huon Peninsula. Karuka nuts are an important part of highlanders' diet during the producing period, being one of the few high protein plant foods in the region. During the harvest, entire households and their domestic pigs often migrate from the main highland valleys up to the high altitude locations.

Karuka grows between 1800 and 2600 m and in locations with a mean annual rainfall from 2000 to 5000 mm. It grows well on poorly drained sites but can also be grown on better drained sites. It is grown as individual trees and in large groves in primary forest and in woody regrowth and cane grass. It does poorly in open sites and short grasslands.



Karuka Screw-Pine, Pandanus julianetti (from 'Roots of the Earth', by Paul Sillitoe)

Production is irregular in the western part of the highlands where changes in the rainfall pattern are slight or absent. In the eastern part of the region where the rainfall is seasonally distributed, production approximates to an annual seasonal pattern, but there is still large year to year variation in the size of the harvest. The biggest harvests have been observed to follow major droughts.

Karuka nuts are very popular amongst the highlanders and, to a lesser extent, amongst outsiders. Unlike galip, most of the available nuts are harvested and consumed. This suggests that commercialisation could have an adverse effect on the quality of the diets of householders who normally harvest and consume the fruit.

With this reservation, karuka is seen as having considerable potential as a commercial nut within PNG in the 1800 to 2600 m altitudinal zone, and possibly in other areas that experience seasonal temperature differences.

Okari (*Terminalia kaernbachii*)

Okari has a limited distribution within PNG. It is very common in inland lowland locations on the central cordillera from the Irian Jaya border in the west to Mt Dayman in the east. It also occurs in a few inland locations on the northern side of the main ranges and in West New Britain between the Aria River and Cape Gloucester.

Okari does poorly near the ocean and grows best in inland lowland and at intermediate altitudes up to 1100 m. This may be due either to a negative effect of salt or a response to the greater diurnal temperature variation that is found away from the coast. It appears to tolerate poor drainage and grows at locations with a wide range of rainfalls from 2000 to 7000 mm.

The production period is quite regular from year to year and is independent of rainfall. There is a close relationship between the start of the production period and latitude, which suggests that it is largely determined by daylength. It is reported that trees at Keravat in New Britain grown from seed from the Northern Province have shown a large variation in nut and kernel characteristics.

Okari nuts are popular in Port Moresby and in other urban centres in the producing region. Given the very extensive stands that occur in many locations in New Guinea, there would appear to be good prospects for commercial development from existing trees.

Polynesian chestnut (*Inocarpus fagifer*)

Polynesian chestnut is widely distributed in the lowlands on the northern side of New Guinea and on all island groups. It is most important in the Bismarck Archipelago and on the islands and mainland of Milne Bay Province.

This tree grows from sea level to 400 m in altitude in coastal and near coastal locations, usually near villages or in woody regrowth. The nut is not popular outside the islands where it is commonly grown and the prospects for commercial development appear only moderate.

Sea almond (*Terminalia catappa*)

Sea almond is widespread in most coastal regions of the New Guinea mainland and islands. It is usually confined to beach areas and village sites near the beach but occasionally grows to 400 m altitude. Most trees are self sown.

In most of PNG, the nuts are eaten only by children or not at all. However, it is most important in the islands of the Milne Bay Province where it is eaten by both adults and children. The production period occurs between November and March with December to February the most commonly reported period.

Prospects for commercial development appear to be reasonably good, particularly if cultivars with soft shells and large kernels, such as are found on the island of Iwa in the Marshall Bennett Group, are used.

Considerable interest has been aroused by the two articles on Bushfoods or Native Foods that were published in the last issue of the Australian New Crops Newsletter. In this article, Larry Geno offers some thoughts on the role that the development of native bush plants might have on their conservation. Larry Geno is an ecologist, Principal of Agroecology Associates and proprietor of Northern Rivers Bush Tucker Foods, Lismore, NSW 2480.

[Based on a paper presented By Dr Michael Bourke at the South Pacific Indigenous Nuts Workshop, Port Vila, Vanuatu, November 1994, and reported in the Australian New Crops Newsletter, No 5, Jan 1996. Sourced via the Internet]

NEW CROPS AS A POSSIBLE SOLUTION FOR THE TROUBLED ISRAELI EXPORT MARKET

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In stimulating articles, Noel Vietmeyer (1986, 1990) pointed out that relatively few plant species, most of which were domesticated thousands of years ago, serve as food for humans and animals, as medicinal plants, and as industrial crops. As a result of atmospheric CO2 increase and global warming, dryer conditions are expected in the future and many existing crop species will unable to survive. Many undeveloped and neglected species could be the new crops of the future, which will tolerate these changing climatic conditions. Research and Development on the development of tolerant crops should be initiated world wide to meet these challenges. New crops should have the potential to thrive in marginal, infertile, dry lands where common crops fail to provide the diversification required to enable sustainable agricultural systems in the future and offer viable commercial opportunities.

Israel is a small country (~ 5 million people and 22,000 km^2) that is self sufficient in agricultural production. The local market is tiny and is subject to dramatic fluctuations in supply and demand. When an extra few tons of fresh fruits and/or vegetables are dumped onto the local markets, prices plummet and farmers cannot make a living. In contrast the export market, mainly Europe, with hundreds of millions of consumers is unlimited from an Israeli point of view. Thus, Israel is basically an export oriented producer. At its peak, the export volume of fresh agriculture produce (mainly fruits, vegetables, and flowers) from Israel was valued around U.S.$ I billion/year. In the 1960s the fruit export industry (mainly citrus, with the famous 'Jaffa' orange being the main product) constituted one of the main sources of foreign currency (out of a total export market of US$211 million, agricultural produce comprised about US$64 million, i.e., 30.3% of the total!).

Today, Israel is an industrial exporting country with total annual export value of US$14 billion, while exports of agricultural fresh produce amount to US$547 million, a mere 3.9% of the total (Statistical Abstracts 1994). It is obvious that a small country such as Israel has to compete in world markets in terms of quality rather than quantity. As a result, millions of R&D dollars have been invested in the past two decades to enable Israel to compete in the world markets with the best possible products giving the highest possible return to the growers. Despite the huge input of R&D in the agricultural sector, the production of the citrus is diminishing (Fig. I) due to lack of profitability (Fig. 2) and farmers are complaining. Citrus sales have diminished by 30.6% from 1990 to 1993 and profitability in terms of revenue's buying power has declined to 57.3% when inflation is taken into account (Fig. 2; Statistical Abstracts 1994; BDO 1995).

Production during this period decreased and prices increased but well below the consumer price index. The inflation rates were 17.6, 18.6, 9.4, and 11.2% for 1990, 1991, 1992, and 1993, respectively (BDO Bavly Milner & Co. 1995). By the time farmers received their money, its value had been eroded due to inflation. The corrected value of their income is calculated from the actual value and the inflation rate.

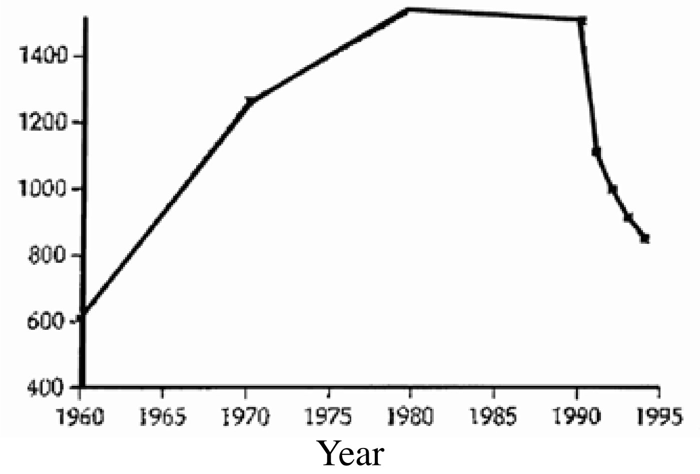

Fig. 1. Changes in annual citrus production in Israel 1960-1994. (Statistical Abstracts of Israel 1994)

The Israeli tomato export industry has stagnated at 8,000 tons annually for the past few years, despite the enormous R&D efforts that have produced the world's finest quality (Statistical Abstracts 1994). Israel has additional cost limitations on its competitiveness. Water is a major limiting factor and its actual price is very high (US$0.22 per m3) and the alternative price is even higher. Labour is very expensive, since farmers are in the upper middle class strata. More than 90% of the agricultural community in Israel is either a kibbutz (community farm) or a moshav (family farm) with minimum hired labour, where most of the work is performed by the farm owners and their families. Gross income below US$100 and even 150 US$/day is considered very low.

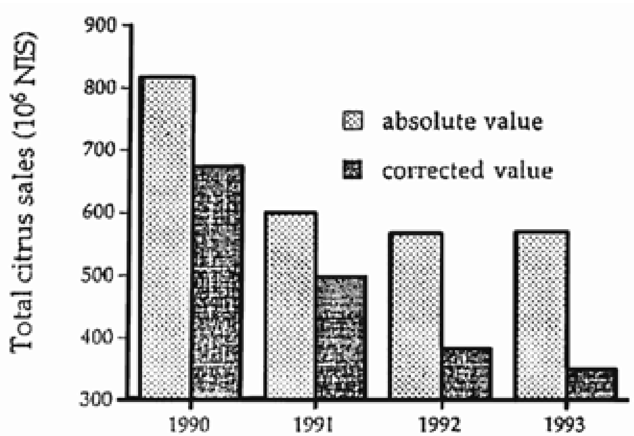

Fig. 2. Changes in sales volume and in buying power of citrus exporters in Israel 1990-1993. Data are taken from the Statistical Abstracts of Israel (1994).

Israel's competitors in the world markets pay to agricultural workers 10% and less of this sum! Finally, energy is expensive, since almost all the country's energy is imported.

These problems have led many experts in Israel to raise the possibility of giving up agricultural production, even for the local markets, and purchasing all the country's agricultural needs abroad, as do Singapore and Hong Kong. We subscribe to a totally different approach. We believe that supplying the new crops niche in the world markets will serve as a remedy for the troubled Israeli agricultural export industry.

PRODUCT PROFIT CYCLE

In a free market every product is following the profit cycle, as described in Fig. 3.

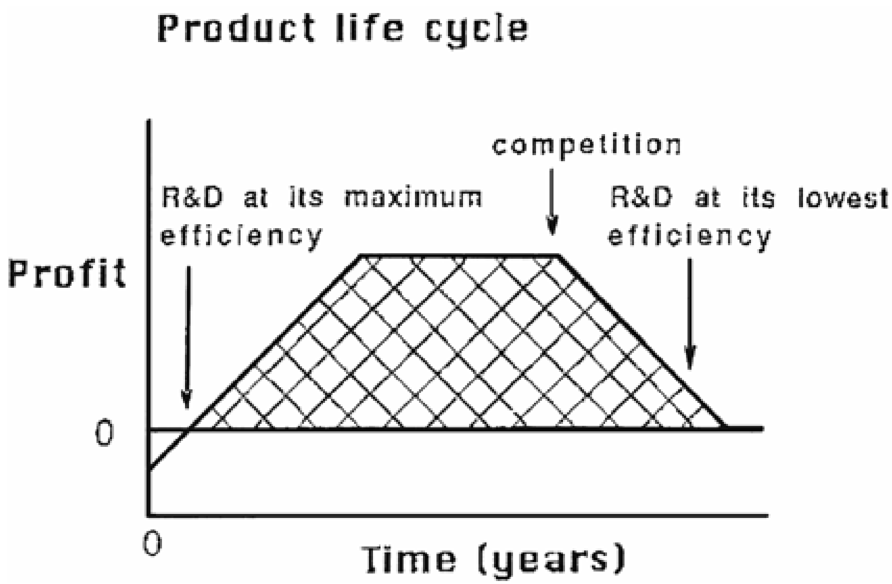

Fig. 3. Hypothetical product life cycle in a free market. For cut flowers exported from Israel to Europe the span is 17 years. (D. Rymon, Agricultural Research).

When a totally new crop is first marketed, no profit is expected, since the market has yet to accustom itself to the product. At this stage, low prices are set to attract consumers. In many cases, the market does not respond to the new product, and it simply vanishes without being noticed by most consumers. But if the market likes the new product (perhaps as a result of good efficiency (Fletcher et al. 1995). Maximum profitability will be achieved by the first producer as long as he is the only supplier in the market. Competition will then start, first with the most efficient and aware producers and from many others. As a result, profitability will decline, and as with all common crops, it will fall to a marginal level. At this stage, only the big and efficient producers can survive. It is thus evident that Israel cannot compete in the market for common crops. A good example of the scenario described above is the "iceberg lettuce episode". In the late 1970's, Marks and Spencer (from the UK) approached the Negev R&D Organisation to test the feasibility of growing iceberg lettuce in the Israeli Negev Desert for their chain. Farmers in the Arava valley (Moshav Ein Yahav and Hatzeva) produced the best Iceberg lettuce that Marks and Spencer had ever received. The company, which was ready to pay these farmers higher prices than those given their American counterparts in California, was mystified by the refusal of the Israeli farmers to accept the contract. The buyers from Marks & Spencer simply did not understand that these farmers depended on very small farms (4 hectares!), expensive water, and very high energy and labour costs. In no way, could they compete with the large American producers.

On the other hand, when we start with a totally new product, the high profits obtained for small quantities of exotic fruits and vegetables, creates a natural niche for Israeli farmers. These farmers, being highly educated, can easily adopt new crops and new technologies. Israel is also blessed with research institutions and extension services capable of carrying an efficient R&D programs, which are essential for the introduction of new crops. In addition, Israel has a single efficient marketing arm of agricultural products (AGREXCO), which can easily adapt to such programs.

Unfortunately, such a strategy has not yet been adopted by the Israeli R&D authorities. The main objection to such R&D programs is the fact that the market size and the prices of the new products are unknown. Our feeling is that such a niche does exist, and the only way to confirm its existence is to test it. Even the return from R&D is expected to be higher when dealing with new crops. We may ask the question: how much can new R&D increase the profitability of well-established crop at the edge of their profit cycle? We claim that such an effort can yield much more when new crops are investigated.

Unfortunately, in Israel as in most other countries, most agricultural R&D is conducted with money raised as levies from sales. Thus apple growers for example, would like to see their money invested back into R&D on apples. The bigger the crop and the greater the body of knowledge about its biological and agricultural aspects, more R&D is applied. As a result, money is allocated mainly to the “good old crops”, while the new crops of the future are neglected. A change in policy is needed to promote more research in the direction of new crops.

NEW CROPS INITIATIVE

In the light of the dilemma discussed above, we initiated in 1984 an R&D project for the “Introduction and domestication of rare and wild fruit and nut trees as new crops to the Israeli Negev Desert” (Nerd et al. 1990; 1993). This project includes about 40 different fruit tree species (Table 1) from all over the world that are considered to be potential new export crops.

Table 1. List of candidate species

FAMILY **Botanical name**	**Common name**	**Distribution**
APOCYNACEAE		
Carissa grandiflora A. DC.	Carissa	Southern America
ANACARDIACEAE		
Cytocarpa edulis	Ciruelo	Baja Ca., Mexico
Harpephyllum caffrum Bernh.	African plum	Southern Africa
Sclerocarya birrea subsp. *caffra* Sonder	Marula (Morula)	Southern Africa
Spondias cytherea (*Spondias dulcis*) Forst	Ambarella	Polynesia
BOMBACACEAE		
Bombax glabra	Malabar nut	Central America
CACTACEAE		
Acanthocereus tetragonus (L.) Humlk.	Acanthocereus	Mexico
Cereus peruvianus (L.) Miller	Apple cactus (Pitaya)	North S. America
Escontria chiotilla (Weber) Britt & Rose	Pitaya (Jiotilla)	Mexico
Hylocereus costaricensis (Weber) Br. & R.	Pitahaya	Central America
Hylocereus polyrhizus (Weber) Br. & R.	Pitahaya	Central America
Hylocereus purpusii (Weber) Br. & R.	Pitahaya	Central America
Hylocereus undatus (Haworth) Br. & R.	Pitahaya	Central America
Myrtillocactus geometrizans (Mart.) Cons.	Pitaya	Mexico
Nopalea cochenillifera (L.) Salm-Dyck	Nopalito, Nopalea	Mexico
Opuntia ficus-indica (L.) Miller	Prickly pear	Trop. America
Opuntia streptocantha Lem.	Prickly pear	Trop. America
Pachycereus pringlei (Berger) Britt & Rose	Cardon pelon	Sonoran Desert
Selenicereus megalanthus (Schum.) Br. & R.	Pitaya	Colombia
Stenocereus griseus (Haw.) Buxb.	Pitaya	Oaxaca Mexico
Stenocereus gummosus (Engelm.) Gilbs.	Pitaya agria	Sonoran Desert
Stenocereus stellatus (Pfeiff.) Riccob.	Pitaya	Mexico
Stenocereus thurberi (Engelm.) Buxb.	Pitaya dulce	Sonoran Desert
Stenocereus thurberi var *litoralis* (E.) B.	Pitaya dulce	Sonoran Desert
CAESALPINIACEAE		
Cordeauxia edulis Hemsl.	Yehib	NE Africa
EBENACEAE		
Diospyros digyna Jacq.	Black sapote	South America
Diospyros mespiliformis Hocht.	Mmilo namibia	South Africa
EUPHORBIACEAE		
Ricinodendron rautanenii Schinz	Mongongo	Southern Africa
FLACOURTIACEAE		
Dovyalis caffra Warb.	Kei apple	Southern Africa
Flacourtia indica Merr.	Governor’s plum	trop. Africa,SE.Asia
LEGUMINOSAE		
Tamarindus indica L.	Tamarind	Tropical Africa
LOGANIACEAE		
Strychnos cocculoides Backer	Monkey orange	Southern Africa
Strychnos spinosa Lam.	Monkey orange	Southern Africa
MIMOSACEAE		
Inga spp.	Ice cream bean	South America

MORACEAE		
Artocarpus heterophyllus Lam.	Jackfruit	Asia
RHAMNACEAE		
Ziziphus mauritiana Lank.	Ber	Old World Tropics
ROSACEAE		
Prunus salicifolia H BK.	Capulin cherry	Mexico
RUBIACEAE		
Vangueria infausta Burch.	Mmilo	Southern Africa
RUTACEAE		
Casimiroa edulis Llave & Lex.	White sapote	Mexico, C. America
SANTALACEAE		
Santalum acuminatum (R. Br.) A. DC.	Quandong	Australia
SAPOTACEAE		
Argania spinosa L.	Argan	Morocco
Manilkara zapota van Royen	Sapodilla	India, Africa & C. America
Mimusops angel Engler	Angel	Somalia
Mimusops zeyheri Sond.	Mmupudu	Southern Africa
Pouteria sapota (Jacq.) Merr.	Mammey sapote	Central America

For the project, four sites were selected in the Negev Desert and one location in the Judean Desert, each site differing from the others in terms of climate, soil and water (Nerd et al. 1990, 1993). The first stage, which lasted about 10 years, was devoted to assessing the survival, growth, phenology, yields and quality of seedlings of the investigated species. For all the species we preferred to start with seedlings, which provide wide base of genetic backgrounds, rather than to concentrate on a very narrow base of vegetatively propagated preselected genotypes.

Many species did not survive, and others are still at various stages of R&D, far away from any considerations of economic potential. Four types of fruit have already been moved to the second stage of this program, which will enable us to provide economic evaluation, such as the cost of various inputs per unit area and the output during the years up to the time that the orchards will reach the full production stage. In this second stage of the project, vegetatively propagated specimens are also being tested in a cultivar trial. The expected small quantities that will be produced at this stage (20-30 tons/year per crop) will also enable us to evaluate the marketing and find solutions to post-harvest problems. The market figures will enable farmers to take decisions whether or not to enter into the arena of these new crops.

The species that are currently in the second stage of the project include: (1) climbing trellised cacti growing in net houses - *Selenicereus megalanthus* and three species of *Hylocereus*; (2) the outdoor-grown cactus *Cereus peruvianus*, also known as apple cactus; (3) white sapote (*Casimiroa edulis*); and (4) Ber (*Ziziphus mauritiana*) also known as “desert apple”, a

species introduced from India. Two more species are under consideration for moving to the second R&D stage: (5) marula (*Sclerocarya birrea* subsp. *caffra*), for which 10 clones are currently being propagated and will be ready for planting next year, and (6) argan (*Argania spinosa*), a wild oil tree from Morocco, which will be promoted to the second stage after the selection of the current fruiting year.

Crawling cacti

These species, which are native to Central and north South America, climb on tree trunks in the tropics and may be epiphytic (Gibson and Nobel 1986). Their fruits have various sizes, tastes, shapes, and colours. Some have spines that abscise upon ripening and others have scales of various shapes and colours. The pulp also varies in colour from white to various hues of red and purple, while the abundant seeds may be soft and edible (Mizrahi et al. 1996). The reproductive biology of these species is described in a review by Nerd and Mizrahi (1996).

Five genotypes are already growing in an area of 2 ha, mainly in net houses since they require shade (Nerd et al. 1990; Raveh et al. 1993; Mizrahi et al. 1996), as described below. One clone of *Selenicereus megalanthus*, also known as yellow pitaya, is being cultivated (Weiss et al. 1995). Yellow pitaya is already an established crop that is being exported worldwide from Colombia (Arcadio 1986; Cacioppo 1990; Mizrahi et al. 1996). Other clones include one of *Hylocereus polyrhizus*, one of *H. undatus* and two of *Hylocereus* sp. (Barbeau 1990), all our selections. These clones have been planted in two plantations, each of 0.5 ha. Each clone was planted in a different row to allow cross pollination from the neighbouring rows (Weiss et al. 1994b). All were planted in the late summer of 1993 as rooted cuttings removed from the same mother plants, and all started to fruit in 1994. In these plantations two net houses were planted, one with 50% shade in the Arava valley, having a hot climate and saline water (EC 4 dS/m), and the other with both 30 and 60% shade sections in the Besor area, which is characterized by good quality water (EC 1 dS/m) and moderate temperatures with only rare frosts (Nerd et al. 1993). The second hectare was planted in the Yad Mordekhay area, with sub-freezing temperatures as low as -4° C; here, plastic houses were planted to accommodate selected and non-selected plants. All started to fruit one year after planting.

Cactus apple

Of many columnar cacti tested by us as potential new crops, one species *Cereus peruvianus* grew the fastest. It started to flower and fruit four years after seeding (Nerd et al. 1993; Weiss et al. 1993) in the Arava valley and the Besor, with a total area of 2 ha. All these cacti were planted as rooted cuttings of seven clones selected from over 300 seedlings. All cuttings were planted as a mixture of clones, since this species demonstrates self-incompatibility (Weiss et al 1994a). The reproductive biology of this cactus is also described in the review of Nerd and Mizrahi (1996). All clones started to flower and fruit two years after planting. Over 1,000 seedlings have been planted for further selection.

White Sapote

White sapote (*Casimiroa edulis*, Rutaceae) is an evergreen medium-size tree native to the highlands of Mexico and Central America. The fruits are green-yellow, with a thin skin and a creamy white-yellow sweet flesh (Morton 1987). Selected clones are available, mainly in Southern California (Chambers 1984; Morton 1987), and some effort has been made to introduce the species into New Zealand and Australia (Dawes and Martin 1988; George et al. 1988). A small commercial plantation (16 hectares) with selected cultivars is being grown in Carpenteria near Santa Barbara, California and the fruits can be found as an exotic item in the United States and Australia. Early tests in the Israeli Negev Desert demonstrated partial tolerance to salinity (Nerd et al. 1992). In autumn 1992 and spring of 1993, 21 grafted clones were planted in Qetura and Besor; 16 were introduced as bud-wood from Fallbrook, Southern California (from R.R. Chambers orchard), while the remaining five were propagated as grafted bud-wood from our own selections. Nine replications from each clone were planted in three blocks at each location. In 1995 some clones started to flower and set fruits in these two locations.

Desert apple

Desert apple (*Ziziphus mauritiana*, Rhamnaceae), also known as Ber or Indian jujube, is an evergreen, medium-size, thorny tree believed to be of African origin (Alexander, 1979). The fruits can reach plum size, turning yellow from green as ripening starts, and becomes sweet and sour in taste, both the flesh texture and taste being reminiscent of apples. The fruit has a unique aroma, similar to that of carob, which becomes too strong for "Western" tasters when fully ripe, at which stage the colour turns brown. The fruit can be consumed dry, similar to its relative the "Chinese date", *Z. jujube*. Ber is grown commercially as a desert crop (hence the name desert apple) in India. Seedlings and introduced cultivars from India developed and yielded very well (over 100 kg/tree annually) in all our introduction orchards, including areas with frequent sub-freezing temperatures and highly saline water (Nerd et al., 1990). Three Indian cultivars were planted at Neot Hakikar, the lowest point on earth -400 m below sea level with 3,960 mm evaporation/year and saline water (EC 4 dS/m) with Na and Cl as the major ions (Nerd et al. 1993). Most of our introduced fruit tree species did not survive under these conditions, but ber has fruited heavily from very early ages. A semi-commercial plantation was planted by a farmer in 1993, and the first yield was sold in 1995 in the local market, mainly to immigrants from India who are familiar with the fruit.

Marula

Marula (*Sclerocarya birrea* subsp. *caffra*, Anacardiaceae) is a large, dioecious, deciduous tree, which grows wild in southern Africa. Female trees bear plum-sized fruits with a thick yellow peel and a translucent, white, highly aromatic sweet-sour fruit, which is eaten fresh, like small mango, or used to prepare juices, jams, conserves, dry fruit rolls, and alcoholic beverages. The seeds, which are eaten as a delicate nut, are highly appreciated by the locals and hence the name "the King's Nut." The nut has high nutritive value and a high oil content (56%) with very good dietetic ratio of saturated to unsaturated fatty acids (Weinert et al. 1990). Trees were established very well at introduction sites in the Negev Desert and produced abundant fruits from early ages, mainly when grown in a hot area with saline water (Qetura) (Nerd and Mizrahi 1993). Trees were badly damaged after a spell of sub-freezing temperatures of -6 and -7°C; all recovered but never set fruits, and thus this species is not recommended for areas with such low temperatures. At Qetura, some pistillate trees are bearing well, over 400 kg/tree annually, and we have moved the species to the second stage of our R&D program to test selected clones on a semi- commercial basis. Ten selected clones are being propagated and will be ready for planting in 1996.

Argan

Argan (*Argania spinosa*, also known as *A. sideroxylon*, Sapotaceae) is a medium, thorny, evergreen tree native to south western Morocco. The tree bears plum-sized fruits, which are eaten by goats which often climb the trees. The fruits have a bitter pericarp around a stone-like structure, containing one to three kernels with a high oil content (over 50%). The oil has high dietetic value, total unsaturated fatty acids/total saturated fatty acids being around 4.5, a ratio similar to that of olive oil (Morton and Voss 1987; Prendergast and Walker 1992). The oil has a unique aroma and is considered as the best culinary oil by Moroccans, who are the only people familiar with the oil. In Israel, where 600,000 immigrants from Morocco reside, imported argan oil is sold for U.S. $43/litre in comparison with $4/litre for olive oil. Attempts to domesticate this wild tree in Israel started about 10 years ago. The species demonstrated adaptability to the hot hostile environment of the Arava valley when irrigated with brackish water; yields of oil per tree at Qetura were double those at Ramat Negev, which has much milder environmental conditions (Nerd et al. 1994). The oil yield of best specimens was around 1 kg/tree per year. Some seedlings died as a result of infection with *Fusarium oxysporum*. Until tolerant rootstocks can be found, we decided to plant grafted trees from the best yielding ones and to plant additional seedlings from various habitats in Morocco. Even though this species is not in as advanced stage of introduction as the marula, we consider it to be a high-priority species because of its rarity and the high demand in Israel for its oil.

CONCLUSIONS

It is interesting to note that in our earliest publication (Nerd et al. 1990), we mentioned six species as promising, an evaluation based on their early development and growth. These species included white sapote and ber, which are still considered promising, and marula, which has been moved to the second stage of the R&D, but they also include yehib (*Cordeauxia edulis*), mongongo (*Ricinodendron rautanenii*), and pitaya agria (*Stenocereus gummosus*), which did not meet our early optimistic expectations. The latter three species proved to be late yielders (pitaya agria); or exhibited sensitivity to the desert conditions of our introduction sites, such as salinity or sub-freezing temperatures; or were not as abundant in fruiting as the promising species described in this presentation. Other promising species emerged, such as *C. peruvianus*, with its adaptability to a spectrum of conditions, including slight salinity and sub-freezing temperatures. The species produces early and heavily, giving good-quality, tasty fruits. The most surprising successes were the various crawling cacti (*Hylocereus* species and *S. megalanthus*), which did not survive the outdoor Negev Desert conditions (Nerd et al. 1990), but once trellised and protected from high radiation by net houses, started yielding precociously and early to give some of the most beautiful fruits on earth.

Of the six promising species from the first R&D stage, three were moved into the second stage (white sapote, ber and marula), while the others emerged as promising, the apple cactus and the crawling cacti. This evaluation was based on fruiting (both as yields and fruit quality) and early selection of good-performing specimens.

We anticipate that at least some of these newly introduced species will become export items with profit levels that will be sufficiently high to revive the fruit export industry and replace the old "dying-out" export crops. The high profitability of new fruit crops was demonstrated for kiwi fruit by New Zealand in the world market and for avocado by Israel in the

European market. There is no reason why such new exotic fruits will not be the commodities of the future. We should not forget that no crop can stay at its peak forever, and low profits always loom in the future. Mr. Dan Rymon (pers. commun.), found that it took 17 years from the first sales of flower crops in the European markets until Israel was chased out by its competitors. With fruit trees, it may be much, much longer, as was the case with the kiwi fruit from New Zealand (47 years) and the 'Shamuti' (Jaffa) orange from Israel (80 years).

We should conclude with an evaluation of the benefits of our program to the world as a whole. Any species that can produce good yields in the Arava valley at the location of both Qetura and Neot Hakikar can serve as a future crop species that can tolerate extremely high temperatures and salinity. Because of the unique situation in the Negev Desert of short distances between agriculturally different ecozones, we recommend that this area be used as a global laboratory for the introduction and acclimation of new desert crops. In 1994 the International Program for Arid Land Agricultural Crops (IPALAC) was initiated under the auspices of UNESCO. This program is aimed at R&D similar to that described in this paper, to be executed with all kinds of agricultural crops in representative desert areas around the globe.

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[Based on a paper presented at *Progress in New Crops*: Proceedings of the 3rd National Symposium, Indianapolis, USA, 1966. Sourced via the Internet]

QUANDONG BECOMES A COMMERCIAL CROP

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Farmers in the drier parts of Australia are looking towards the Quandong as an alternative crop. Years of research into this native plant have resulted in improved plant varieties and techniques to propagate the trees on a commercial scale. Now scientists are trying to find a host that will suit commercial cultivation.

Also called the Bush Peach or Native Peach, the quandong (*Santalum acuminatum*), could be the next Australian bush food to whet international appetites.

Turning a wild resource into a sophisticated horticultural crop is challenging a devoted group of Australian quandong producers and research scientists who believe the quandong has potential to emulate the success of another Australian native bush food - the macadamia. But, whereas the macadamia had to be exported to Hawaii before it became established as a successful crop, the quandong industry hopes to achieve its success in Australia. (Already quandong seed is being propagated in the United States and trees being selected for commercial production there.)

The quandong is native to arid Australia and although it has long been recognised as a delicacy by indigenous and rural Australians, it is still largely unexploited.

The idea of commercialising it is nothing new - at the turn of the century botanist Joseph Maiden suggested that there was potential to cultivate the tree: The CSIRO Division of Horticulture has studied the horticultural potential of the quandong since 1973; establishing experimental orchards, selecting plants on performance, and developing ways of propagating the trees on a commercial scale.

While commercial orchards are being established around the country, the development of the industry is still in its infancy. Most of the estimated 10 tonnes of quandongs harvested each year are sourced from wild trees, according to the Australian Quandong Industry Association.

Formed in 1992, the Association helps growers to set industry standards, overcome some of the challenges they face in domesticating a native resource and to promote their product.

While it will be some time before every supermarket has a stock of quandong products, the current wholesale price of up to $60/kg for dried fruit, could make the crop an attractive alternative for farmers in drier parts of Australia. The establishment of commercial orchards could also protect the species from the threats of overgrazing by domestic and feral animals in the wild.


Quandong fruit and leaves

The quandong is found in the drier areas of all Australian mainland states. A root parasite, it is a small tree that produces fruit with a pitted stone containing an edible nut. The flesh usually has a red skin but can vary in colour from bright yellow through to pink and dark red.

Quandongs have been harvested as a food for as long as people have lived in Australia. The traditional diet of many Aborigines includes both the fruit and nuts, while European settlers stewed the fruit and used it in jams and pies. The flesh is rich in vitamin C - about twice as much as oranges - and the nut contains high levels of oil (56-67%) and protein (13-19%).

Fresh quandongs have a distinctive acidic taste and most people prefer to eat fruit which has been stewed, dried or processed into jams or pickles. The nut can be eaten roasted or raw but often has an unpleasant aftertaste and smell caused by the presence of methyl benzoate. The trees flower from November to March and the fruit ripens between August and November.

Quandongs prefer well drained soil, although a reliable water source is needed to establish them during their first summer. Older trees are very salt and drought tolerant, surviving on very little or poor quality water. These characteristics enhance quandong's potential as a horticultural crop for farmers in the drier parts of Australia.

Plant selections

The enormous variation between trees growing in the wild has highlighted the need to carefully select trees for high yields, large fruit, a high percentage of flesh, good fruit shape, rain tolerance and a pleasant taste.

In the early 1970s the CSIRO Division of Horticulture, with the collaboration of interested growers, used seed from wild quandongs growing around Australia to establish a series of experimental orchards at Adelaide, Quorn, Strathalbyn and Paringa in South Australia, at Merbein and Koorlong in Victoria and at Coomealla in New South Wales. The orchards gave researchers the opportunity to identify individual quandong trees with potential for commercial orchard production. Superior trees were capable of producing up to 20 kilograms of fruit per tree with up to 70%) flesh.

The oldest orchard in the network at Quorn at the southern end of the Flinders Ranges, was planted in 1974 and was established primarily from seed collected in the southern Flinders Ranges. The trees were grown using saline irrigation water (EC of 4776 microSiemens/cm with 1264 mg per litre of chloride). Genetic variation in the trees sourced from the wild resulted in a collection of more than 360 different types which varied in their ability to thrive, mature tree height and form, leaf shape and colour, years to first fruiting and in the number of fruit per tree. Some trees had not fruited after 7 years while others came into production after 3 years and some only fruited every second year. There was also enormous variability in the number of fruit per tree (0-1,500) and fruit maturity - on some trees fruit matured in late July, while on others, fruit was still maturing in December.

The trees also varied in their ability to tolerate rain damage on the skin with fruit on some trees showing no damage after heavy rain and on others, severe damage after just light rain.

Trees in the CSIRO experimental orchards were individually hand picked and the fruit assessed for flesh and nut flavour, fruit diameter, length and weight, flesh thickness, fresh and dry weight, stone diameter and weight. The researchers found that not only did the fruit on one tree differ from that on the next, but that variation occurred on individual trees. The estimated yield, based on the best trees at Quorn, planted at 200 trees per hectare, was 5 tonnes/ha of dried fruit. Conservatively valuing the dried fruit at $30 a kilogram meant the quandongs had the potential to gross in the order of $15,000 a hectare.

At sites where quandongs were grown under irrigation, high tree planting densities of 800 trees per hectare and higher yields of 4 kg of dried fruit per tree, highlighted the scope to increase gross returns.

Propagation

But, realising the potential of outstanding trees identified in the CSIRO orchards hinges on successfully propagating superior selections for large scale commercial production.

Research into different techniques for propagating quandongs has shown that grafting is the most reliable way of reproducing superior plants. Although CSIRO scientists have developed successful methods of germinating seed, quandongs grown from seed do not produce true to the type of the parent tree. So growers must wait until seedlings mature and bear fruit before being able to assess their commercial merit. Tissue culture, while possible, has so far failed as a way of economically mass producing outstanding trees. The main problem has been a low percentage of root initiation in the tissue culture medium.

Grafting trees, using techniques developed by CSIRO, has proven a far more reliable way of propagating genetically superior quandongs.

Quandong flowers and germinating nut

Sunraysia Nursery develops quandong potential

Ask Peter Smith about quandongs and his eyes glint in excitement. With almost 10 years practical experience, the owner of the Sunraysia Nursery at Gol Gol in New South Wales is at the cutting edge of commercial quandong propagation.

While the basis of his business is supplying citrus, grapevines, avocados, olives, pistachios and stonefruit trees to the horticultural industry in the region, he is one of the few commercial nurserymen propagating CSIRO selected quandongs and supplying them to commercial growers.

Last year's sale of 3500 quandong trees pales into insignificance when compared to the sales of citrus and vines, but Mr Smith is convinced that quandongs have an exciting future as a commercial horticultural crop and he is making a considerable investment in the plant's commercial development. He is one of the few people in Australia who have commercialised propagation techniques developed by CSIRO.

Building up commercially marketable numbers of productive trees has involved using selections made by CSIRO at an orchard at Koorlong in Victoria. The orchard's 600 trees were grown from seed collected from selected parents in the wild. From the orchard, CSIRO identified 15 superior trees and these selections formed the basis of the genetic material used by the Sunraysia Nursery.

Grafting from 15 individual trees was the only viable way of replicating the superior selection, so building up large numbers of trees was a long term proposition. To speed up the process, the Sunraysia Nursery established its own orchard of the superior selections in 1993 to produce commercial quantities of grafting material. But problems arose due to an overall lack of knowledge about the plant.

"When we established the orchard we chose an exotic perennial creeper as the host because both the creeper and the quandong flowered at the same time and we thought this might enhance pollination. But it was the wrong combination - the creeper needed regular irrigation to survive but, being a desert plant, the quandong didn't like regular irrigation as a result we lost trees from over-watering ", Mr Smith said.

"We're now using a desert plant as the host and it makes irrigation management much easier." The orchard will ultimately act as a source of fruitwhen it comes into full production, but for now the fruit is being collected for its seed for further propagation and selection. Mr Smith hopes to find plants that have an ability to cope with wet, saline conditions with the aim of producing trees and rootstock capable of growing with saline irrigation water.

The young quandongs sold for commercial cultivation by the Sunraysia Nursery take two years to reach a saleable size and are potted with a host.

At $7.50 a tree, most sell to dryland farmers who want to try a small number of trees as a potential alternative source of farm income.

The nursery has sold trees to South Australia, south west Queensland. western New South Wales and the Victorian Mallee.

"Growers are effectively road-testing this new horticultural crop under different management systems with different host ranges and under a cross section of climates". according to Mr Smith.

Young trees, grafted in a glass house, produced fruit two years after planting in field trials at Koorlong.

Commercial nurserymen are now producing grafted quandongs, based on selections made from the CSIRO experimental orchards under licence and selling them to growers. The only drawback with this approach has been the time needed to build up adequate stocks of suitable scion grafting material. While this has slowed the commercialisation of selected trees, grafting has given the industry some flexibility by allowing growers to use different combinations of scions and rootstocks to produce trees which suit their soil and water conditions and are capable of producing high yields of commercially acceptable fruit.

Host relationship

Research into successfully propagating quandongs has also involved studies of the role of the host plant. Quandongs can grow successfully without a host for the first year, but from then on a relationship with a host plant appears crucial for the tree to develop and thrive. Quandongs appear to have a wide host range - they can tap into the roots of Eucalyptus, Acacia and Casuarina when growing wild or can form a host-parasite relationship with any backyard fruit tree or shrub, perennial or annual grass.

When a quandong root comes in contact with the root of another plant, the quandong produces a pad-like growth which adheres to the root of the host allowing root tissues to invade the host's roots. It is not fully understood what the quandong gets from the host or if some plants act as better hosts than others. The roots of quandongs are particularly susceptible to fungal infections and the host may give the tree some protection. Flinders University PhD student Ms Beth Byrne is investigating the quandong-host relationship with the aim of finding a host which suits commercial quandong cultivation. Her research involves studying the quandong and its hosts at a number of sites in the wild, as well as the CSIRO orchard at Merbein.

Kikuyu grass has been used as a host for quandongs in the past and while it is effective, it poses management problems for commercial orchardists, especially under irrigated conditions. One species showing promise in the Flinders University study is a native creeper called Myoporum which forms a dense ground cover and favours the same climatic conditions as the quandong.

The future

While past research by CSIRO and grower experience is helping the quandong industry to develop management recommendations, research and development is still needed to realise the crop's potential for large scale production.

Commercial nurserymen are undertaking tree selection, searching for trees with the right types of ripening pattern, growth habit for harvesting ease, and pest and disease resistance. With the exception of some trees which drop their fruit, most quandongs are harvested by hand which can be expensive and time consuming. The fruit do not ripen once they are picked so it is important to only harvest mature fruit with fully developed sugar levels. Selecting trees with short ripening times can potentially reduce harvesting times and costs.

Processing quandong fruit is time consuming, labour intensive and almost all done by hand. The fruit is cut to remove the stone and spread on racks to dry in the sun. While there are a number of commercial cutters and driers available, modifications will be necessary

Quandongs: the traditional diet of Aborigines includes the fruit and nuts. European settlers stewed the fruit and used it in jams and pies.

for handling large quantities of fruit. More research is needed to investigate the potential of mechanical harvesting, and improved processing and drying methods, if quandongs are to be produced on a large scale.

The future of the quandong as a commercial horticultural crop hinges on producing consistent quality, clean fruit. Quality control is emerging as a key issue for the industry. With large volumes of quandongs still being harvested from the wild, the quality of the fruit is highly variable.

High prices for dried quandongs have meant that wild fruit which has rain or insect damage is still saleable and this is effectively discouraging the establishment of commercial quandong orchards.

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[Based on an article in CSIRO's magazine Rural Research *No. 172, Spring 1966*]

SILVOPASTORAL AGROFORESTRY USING HONEYLOCUST (GLEDITSIA TRIACANTHOS L.)

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Agroforestry systems integrate trees with traditional agricultural practices. Such land use systems are economically viable when the combined value of agricultural crops and tree products is greater than the value of either product grown alone. In tropical climates, agroforestry has often been an integral part of indigenous agriculture and has in recent times gathered wide support from international development agencies.

Presently there are relatively few commercial temperate zone agroforestry practitioners. Recently, ecological and financial difficulties in traditional agriculture have led to increased interest in agroforestry by the scientific community and others. These difficulties include continuing soil erosion, falling productivity, increasing cost of petrochemical inputs, and environmental concerns related to the use of chemicals. Agroforestry practices can contribute to the goal of agricultural sustainability by reducing soil erosion and increasing farm profits.

In temperate zone agroforestry, silvopastoral systems predominate [4, 21], and have relevance because of the large area devoted to grazing. At present, temperate zone silvopastoral systems are for the most part limited to pasturing cattle and sheep in plantings with appropriately spaced timber trees. In areas where these systems are inappropriate, alternative pastoral agroforestry designs are needed.

Silvopastoral Honeylocust Design

One potentially productive temperate zone agroforestry system is establishment of honeylocust orchards in operating pastures or hay fields [9, 37]. Using operating pastures allows normal cash flows from animal and hay production to continue while the honeylocust orchard matures.

Honeylocust trees produce pods which livestock can harvest from under the trees. Pods drop gradually from trees over several months in autumn, and harvesting costs are nil. The pods thus provide livestock with a complementary feed source when seasonal grass production is declining. Although not easily quantified, additional benefits from silvopastoral honey locust include reduction of water runoff and topsoil erosion, shade for livestock, a productive pollen and nectar source for bees, a more diversified and aesthetically pleasing pasture environment, and timber upon project termination.

Experimentation to test the efficiency of silvopastoral honeylocust is currently taking place in several temperate zone countries (Table 1). In addition, preliminary trials with

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honey locust have also taken place in China (D.R. Bird, personal communication), India (F. Santamour, personal communication), and Pakistan [15], but details are not available. A majority of the current experiments have established honey locust orchards directly in pastures with animals, and are simultaneously evaluating several cultivars as well as a variety of cultural regimes. A variety of other system components are also being evaluated, including tree establishment techniques, tree spacing and pruning, fertilizer applications and insect control programs.

Present research is concentrated in economically developed countries; ultimately, much of this work should have application in temperate regions of developing countries as well. Most research is publicly financed; however, because of the need for direct evaluation in pastures with animals, cooperating farmers are playing an increasingly important role.

When silvopastoral orchards are established in working pastures, young trees need protection from livestock browsing and rubbing. In current experiments, three tree protection strategies are being evaluated: plastic tree shelters, electric fences, and the natural thorns presented by honeylocust. In extensive trials in the United Kingdom, plastic tree shelters have proven effective in hardwood pasture plantings with sheep and cattle [28] and are now being evaluated in honeylocust pasture orchards (C. Dupraz, personal communication). Where electric fences are used to subdivide pastures for intensive grazing and rotation, these fences provide the basis for a less expensive method of protecting trees. While more expensive, plastic tree shelters permit a greater tree density (75 per ha in some trials) since trees can be planted throughout the pasture. In developing countries where tree shelters and electric fences may prove too costly, honeylocust's natural thorns are a viable alternative.

Honeylocust Characteristics

Honeylocust has a number of characteristics which recommend it as a silvopastoral agroforestry species [13,26,37]. Honeylocust is adaptable to a wide range of climates within the temperate zone. While native to most of the Mississippi Valley, honey locust is now found in all areas of the continental United States as well as most other temperate zone countries [5]. Honeylocust is winter hardy to temperatures below -34°C. It is drought resistant (the natural range includes areas with 51 cm annual precipitation) and has good storm survival characteristics [5].

Honeylocust thrives in a variety of soils, although it grows poorly on shallow, gravely, or heavy clay soils. Honey locust does well in alkaline soils, preferring a soil pH of 6.0 to 8 0, and is tolerant to acid soils and salinity. In laboratory tests, honeylocust grown at low pH have proven to be more susceptible to aluminium toxicity than any other species tested [33]. Honeylocust may prove valuable as a bellwether species for declining pH caused by acid rain or other factors.

Honeylocust leaves and flowers appear late in the spring, and spring frost damage is not normal. Planting honeylocust in frost pockets, however, should be avoided. Honeylocust naturally produce thorns (up to 45 cm) dangerous to livestock and tractor tyres. Thornless trees can be produced by budding with scion wood taken from the thornless upper branches of the desired cultivars. While in the legume family, honeylocust does not produce nitrogen-fixing nodules.

Honeylocust is polygamo-dioecious. For complete pollination, predominantly staminate trees must be included in honey locust orchards. Techniques for clonal reproduction of honey locust using budding have been perfected in commercial nurseries. Reproduction is also possible by grafting, root cuttings and greenwood cuttings [32]. Work with tissue culture reproduction has begun in France and in the United States (C. Borgman, personal communication).

Honeylocust's open canopy produces a light shade, minimizing the negative effect on summer grass production. Casual observations of field workers suggest that pasture grasses and legumes do well under honey locust, growing right up to the trunk of the tree. The only study of pasture grass production under a honey locust orchard yielded inconclusive results [37, 38]. Late spring leaf-out and early leaf drop in fall minimize shading during these seasons. In addition, the tree's small leaflets are easily absorbed into pasture grasses during autumn leafdrop and provide an additional source of pasture fertilization.

Because honey locust has been planted world-wide as a temperate zone urban shade tree, an extensive literature exists on propagation, planting, fertilization, and disease and insect control. A literature search in the Commonwealth Agricultural Bulletin data base for the years 1972-1992 found 295 entries for *G. triacanthos* L. This literature is available to facilitate adoption of honeylocust in agroforestry settings.

Pod Yield and Nutrition

Information on honey locust pod production is incomplete, often based on studies of isolated trees and for single years, and is often anecdotal. Information in Table 2, however, indicates that honeylocust has good pod production under a variety of conditions. Reports of higher and lower pod yields are available [8,19]. Pod production is strongly biennial [26]. Pruning regimes, planting of several cultivars, and selecting improved cultivars may reduce biennial yield patterns [27].

Studies in controlled stanchion and barnyard settings in the U.S., South Africa and France have, with one exception, produced positive results from feeding honeylocust pods to cattle, dairy cows and sheep [9, 20, 26, 29, 35]. Sheep have an ability and desire to consume the pods. In French and South African trials, sheep ate between 0.75 kg and 2.0 kg of pods per day [9, 35]. Sheep can also digest between 70% and 90% of the honeylocust seed, fed in pod or shelled [9, 29, 30]. For sheep, 6.9% of ground pods from unselected seedlings is digestible protein (Table 3). Cattle and swine will also consume honey locust pods but do not digest the seeds. No toxicity problems have been uncovered in trials to date [9, 35] (G. Phillips, unpublished).

Conclusions and Discussion

Honeylocust has often been recommended as a temperate zone agroforestry species with high potential [11, 13, 31, 36]. Sufficient information to recommend commercial adoption, however, has been lacking. Past studies, while giving promising results, often were discontinued before mature trees could be evaluated. Both the number and sophistication of present studies, being conducted under a variety of soil, climate and cultural conditions, give promise that within the next decade the cumulative results of these studies will offer an improved guide to the commercial value of silvopastoral honey locust. An important next step will be compilation of findings from the present experiments, including information on effects of soil, climate, cultural techniques, and performance of various cultivars. Towards this end, the author has organized the Honeylocust Research Group to improve communications and systematize data collection among professional and amateur researchers. Following is a brief summary of progress to date, with remarks on further work needed.

Table 1. Research with silvopastoral honeylocust*

Country (State)	Year	Trees	Agroforestry system	Reference
ALGERIA				
Dahra	1956-	98 G{2}	Pasture orchard	[24] (Dupraz, PC)
AUSTRALIA				
Victoria	1987-	200	Pasture orchard	(J. Alexandra, PC)
NSW	1990-	50 G{4}	Pasture orchard	(R. Lance, PC)
BHUTAN			Introduction trial	[25]
FRANCE				
Herault	1987-	192 G{16}	Experimental orchard	[9] (C. Dupraz, PC)
Herault	1992-	147 G{12}	Pasture orchard	[10] (C. Dupraz, PC)
Herault	1992-	139 G{13}	Pasture orchard	[10] (C. Dupraz,PC)
Herault	..	(4 ha)	Pasture orchard	(C. Dupraz, PC)
GERMANY				
Nuremberg	1990-	20 G{5}	Cultivar evaluation	(W. Griesmeir, PC)
GREECE				
Macedonia	1992-	50 G{10}	Pasture orchard	[10] (C. Dupraz, PC)
Macedonia	1992-	50 G{10}	Pasture orchard	[10] (C. Dupraz, PC)
NEPAL				
Jajarkot	1991-		Introduction trial	(C. Edwards, PC)
NEW ZEALAND				
East Coast	1985-	79 G {12}	Pasture orchard	(R.J. Hall, PC)
So Auckland	1958-	-	Pasture orchard & fencerow	[17](T Lennard,PC)
SOUTH AFRICA				
Orange Free St.	1940-60	135		[20]
Natal..			Demonstration project	(T.M. Maliehe, PC)
Transvaal	1908-?	81	Experimental orchard	[23]
Transvaal	1940-60	500	Hayfield orchard [35]	
Transvaal	1953-	750	Hayfield orchard [18]	(Grootfontein College, PC)
SPAIN				
Almeria	1988-1989		Introduction trial	[14]
UNITED STATES				
Alabama	1938-47	95 G{2}	Hayfield orchard	[19] [26]
Arkansas	1982	80 G{2}	Mowed orchard	(K. Ladd. PC) [34]
Illinois	1941	200 G{5}	Fenceline	[16] (R. Kreider, PC)
Michigan	1982-	.. (4.3 ha)	Provenance study	[13] (M. Gold, PC)
Minnesota	1990-	60 G{15}	Pasture fence lines	(P. Van Wazer, PC)
Tennessee	1982-	55 G{3}	Mowed orchard	(H. Black, PC) [34]
Virginia	1939-55	160G{1}	Pasture orchard	[38]
Virginia	1984-	60G(6)	Pasture fencelines	[37]

*G{n} indicates grafted trees and number of cultivars under trial. "Pasture" indicates systems with domestic livestock. PC = personal communication.

Silvopastoral honeylocust and sheep

Sheep appear to offer the best fit with silvopastoral honeylocust, primarily because they can digest the honey locust seed. Because of their smaller size, sheep require less expensive tree protection. The sheep reproduction cycle also coincides with pod production: pods can be fed appropriately in autumn to flushing ewes or weaned lambs. For cattle and swine to receive full nutrient value, pods must be machine harvested and processed [27].

Tree protection systems

The effectiveness and relative costs of alternative tree protection systems are being evaluated in the present trials. Especially important in developing countries will be the effectiveness of natural thorns to protect trees. Further work is also needed to determine the need and type of protection for mature pastoral honey locust [16]. Glue-based paint products designed to repel livestock have been developed and are being tested in silvopastoral settings (R. Sheldrick, personal communication).

Pod production

While pod yields are significant (Table 2), more precise data are needed for pod production on specific cultivars and on a per hectare basis for various planting regimes. Measuring pod production from isolated trees may give unrealistically high yields. The development of standardized techniques for estimating yields from orchard trees will facilitate the comparison of results.

Table 2. Honeylocust pod yields (dry weight).

Location	Kg/tree	Tree age span	Setting	Reference
Australia*	25-30	8	Isolated	[12] .
	100	12	Isolated	[12]
France*	34	10-50	Isolated	[9]
South Africa	32	9-12	Orchard	[35]
United States				
Millwood	33	5- 10	Orchard	[26]
Calhoun	14	5- 10	Orchard	[26]
Millwood	43	9- 10	Orchard	[26]
Calhoun	16	9- 10	Orchard	[26]
United States	38	31-34	Isolated	A. Wilson. unpub.

*Reported single year figures have been reduced by one half to adjust for honeylocust biennial bearing pattern.

Table 3. Nutritional composition for sheep of ground honeylocust pods and seeds from unselected trees (dry weight basis)*.

Crude fibre	18.2 %
Protein (N x 6.25)	10.5%
Digestible protein	6.9%
Digestible energy (Mcal kg-l)	3.3
Metabolizable energy (Mcal kg-l)	2.7
Total digestible nutrients	74.1 %

*88.4% of this pod sample was dry matter. Values were computed from equations, not experimentally. Source: [22].

Fertilization regimes to increase pod yields, and the cost effectiveness of these regimes, are being evaluated. For proper seed formation, trees with staminate flowers must be part of the honey locust orchard. In current trials, the percentage of staminate trees ranges from 7% to 12% [17].

Cultivar selection

The honey locust displays a high degree of variability [13,26] making it a good candidate for further cultivar selection.

Toward this end, Gold at Michigan State University has established a provenance, half-sib progeny planting containing 250 sources, presently in its tenth year [13].

Presently, 42 honey locust cultivars selected in France, New Zealand, Australia, South Africa, and the United States are being evaluated in pasture trials with animals (Table 1). An international exchange of seed, scion wood and grafted trees is under way. Important cultivar selection criteria include high pod production, high pod protein, acceptability to livestock, and insect resistance. Especially important will be selection to minimize biennial yield fluctuations.

Feeding trials in both pastures and stanchions have begun and will play an important role in cultivar selection [9, 35]. Cultivar response to various soil types and climates will also be important. For example, cultivar selections from the southern United States, when planted in northern regions, have produced lower yields and pods with lower sugar content, as well as having suffered winter die-back [8].

With appropriate management practices, average annual pod production of 40 kg for 10 year old orchard trees appears possible. A planting of 75 trees/ha, excluding staminate trees, would yield 3,000 kg. This output would provide 100 sheep a 1.5 kg ration for 20 days.

Pasture management

The effects on grass production of tree shading and competition for soil moisture and nutrients are major concerns in silvopastoral agroforestry systems. Tree spacing and pruning are the design variables most likely to affect pasture grass production. Spacing in the present trials ranges from 5 to 10 metres square in pasture orchards and 3 to 10 metres in fencerow plantings. In some climates honey locust' s mottled shade may positively affect grass production (R. Lance, personal communication). Two studies have suggested that trees will affect the distribution of grass production by concentrating the grazing and resting patterns of animals around trees [38] (J. Law and R. Sheldrick, unpublished). Selection of appropriate understory grass and legume species will be a priority.

It has been suggested that using honey locust pods as animal food will lead to the spread of thorny and unwanted seedlings in pastures [3, 19]. Most farmers presently consider honey locust undesirable and remove them. Five pastures with bearing honey locust are being monitored as part of an informal survey, and some problems have been observed. Seedlings are largely controlled by livestock grazing.

Insect and disease problems

A number of insects and diseases have been identified in the literature as potential problems affecting honeylocust growth and pod production [5, 7]. The widespread use of honey locust as an urban shade tree has increased the number and severity of insect and disease problems encountered. Pure stands of honey locust in pasture orchards may be susceptible to severe disease and insect damage. Orchard trials will indicate these effects on pod production, and subsequently the need and cost of appropriate control programs.

Alternative scenarios

Silvopastoral honey locust can be used to produce several alternative outputs: pods and/or leaf fodder [21 for animal feed, fermentation of pods in ethanol production [27], pollarding for firewood [6], and trees as part of a windbreak system [3]. Currently, the most viable alternatives are windbreaks and pod production for animal feed. Experience gained in current trials with pasture honeylocust for pod production can, however, be applied to leaf and twig fodder, energy, and firewood systems should such outputs prove to be economically viable.

Economics

Ultimately the efficiency of silvopastoral honeylocust will be determined by the ability of this system to increase farm profits. Preliminary economic analysis reported earlier [37], using a variety of cost and production assumptions, indicates internal rates of return of between 9% and 25% for pasture honey locust projects. These rates of return are based on conservative assumptions concerning pod yields and it seems likely that they will be equalled in current trials. As these trials provide additional pod yield and nutritional data, further refinement of this analysis will be possible. The "service benefits" enumerated above have not been included in the analysis but clearly add to the desirability of silvopastoral honey locust.

Acknowledgements

Special thanks to Jim Allen, Gene Hunter, and Ruth Klippstein for their suggestions, and also to Greg Williams for his long-term support of this research project.

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[Based on a paper in *Opportunities for Agroforestry in the Temperate Zone Worldwide*: Proceedings of the Third North American Agroforestry Conference, August 15-18, 1993, Iowa State University, Ames, Iowa. Richard C. Schultz and Joe P. Colletti, Editors, 1994]

PERSIMMON PRODUCTION IN CHINA

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There are about 64 species of *Diospyros* L. native in China. Kaki or Japanese persimmon (*Diospyros kaki* L.) is the main species cultured for edible fruit production in northern China. The primary commercial persimmon production area is about 66,000 ha along the Yellow River. Average annual production of persimmon fruit is about 730,000 tonnes. Approximately 70 to 80 percent of the crop is marketed as fresh fruits from September through February. The remaining fruit are processed (dried, preserved, wine, juice, in cake, etc.). The current (1994) market price in China is about 25 U.S. cents for 1 kg fresh weight.

Climatic Adaptation

Temperature. Climate is the major determining factor for persimmon production in China. Temperature, spring frost, wind, and hail are the major climatic factors affecting persimmon production. Kaki persimmon can grow where the average annual temperature is between 10 to 22°C and grow best between 13 to 19°C. Dormant persimmon trees can tolerate -16 to -20°C without any damage. However, new shoots are very susceptible to injury by spring frosts. The fruit needs 23 to 26°C for developing and 13 to 20°C for maturing. High temperatures in the fall will cause thicker skins and a lighter coloured fruit flesh with more brown spots.

Rainfall. In non-irrigated land, persimmon trees need more than 500 mm of annual precipitation. New roots will not develop if the water content of the soil is less than 16 percent. Too much rain and a lack of available sunlight during the growing season will cause poor setting of fruits, bland flavour, and poor differentiation of flower buds for next year.

Wind and Hail. Strong wind can destroy the flowers and fruits. Tree defoliation by high winds or hail will reduce the crop the following year.

Persimmon Cultivars

Persimmon cultivars are divided into two types - astringent and nonastringent. Most Chinese cultivars belong to the astringent type. To remove astringency, persimmon fruit are treated to transform soluble tannins into insoluble ones ('after-ripening' or 'depuckering').

There are about 800 cultivars in China, but some cultivars have different names in different provinces. For example, Cai persimmon has more than six names including Cap, He, Zhong Tai, Ou and Belt. Below are descriptions of some of China's most important cultivars.

Cai. Cai persimmon grows in northern China, mainly north of Tai Hang and south of Yan Mountain. When the fruit of Cai is exported it is under the brand name "Beijing Honey" persImmon.

The tree is upright in growth, with a round crown. Shoots are thick and expanded leaves are oval in shape. Fruits are very large. averaging about 250 g each. The largest fruit can be 500 g. The fruit has light yellow flesh with thick skin. The flesh is sweet, juicy, and tender. The fruit ripens in late October with a good keeping and shipping quality. Trees perform best in deep fertile soil without pollinizer trees. Major production problems for this cultivar include alternate bearing and susceptibility to wind and hail damage. It is one of the hardiest persimmon cultivars in northern China.

Nin Xing (Cordate Persimmon). Nin Xing is an important cultivar in Shanxi, Shaanxi, and Henan Provinces. The tree is spreading with sparse branching. Precocious and high yielding, Nin Xing produces large fruit (120 g). These fruits are marketed both in the fresh and dried state (100 kg fresh fruit can be processed to 40 kg of dried fruit). The fruit ripens in early , October and has an orange-red flesh with a sweet juicy flavour. The tree is quite resistant to flooding, and seems to grow better than other cultivars in high rainfall regions. It is difficult to solidify the soluble tannin in fresh fruit.

July. July is grown in Shaanxi and Henan Provinces. The tree has medium vigour with dark green leaves. The fruit is large (180 g) with a flat shape and a pointed top. It is thin skinned, juicy, sweet, and tender. It is harvested in late August. Fruits are too soft to store and transport. The fruit is only sold in local markets.

Board. Board produces large flat fruits with four lobes. Fruit ripens in August and is easily after-ripened. Fruit can be eaten in the crisp state.

Huo Guan (Round Persimmon). Huo Guan produces small seedless fruit with smooth red skin and red flesh. Yields are high and fruit store and transport well.

Wu Huan (Five-Lobe Persimmon). Wu Huan always produces two kinds of fruits on one tree. Large fruits come from imperfect flowers and small fruits come from perfect flowers. This cultivar produces high yields of medium-size fruit with five lobes.

Zhe Jia Hong (Home Persimmon). Zhe Jia Hong is characterized by high yields, early maturity of fruit, and ease of after-ripening. The medium-size (95 g) fruit with red-orange flesh is eaten in a soft state.

Two Most Hardy Cultivars. Denglong (Lantern) persimmon and Huoguantou persimmon are the most cold hardy cultivars grown in Shanxi. Shoots of these cultivars can stand a short time (12 hours) of 17°C without injury.

[Based on an article in the Northern Nut Growers Association *1994 Annual Report*. Zheli Wang is Director/ Pomologist of the Center for Forestry Science]

THE NUT INDUSTRIES OF RUSSIA (Part 1)

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Introduction

The value of nuts as a food product is exceptionally great, because of the high content of fats (40-50%), proteins (12-23%), carbohydrates (5-25%), vitamins A and B. In fact, nuts are an indispensable natural food concentrate that is equal to bread, meat and milk in nutrition. Not without reason, the great biologist of the 20th century, Nikolai Vavilov, considered nuts the "bread of the future". Travellers, sportsmen and astronauts always include nuts in their menus.

On the territory of the former USSR nut crops occupied a relatively small area - about 165000 hectares or 3% of the total fruit crop area. The actual yield of the nuts was slightly more than 125000 tonnes. That was sufficient neither for the consumption of the population, nor for the food industry (Yadrov, 1987).

For all that the recommended level of nuts consumption is 2.4 kg per capita, the real production was only 0.2 kg or 12 times less (Morozov, 1983).

The main nut crop on the territory of the former USSR is hazel (*Corylus avellana*), which occupies 58% of the total area, followed by the walnut (*Juglans regia*) - 32%, the almond (*Amygdalus communis*) - 7.5%, the chestnut (*Castanea sativa*) - 1.0% and the pistachio (*Pistacia vera*) - 1.0% (Kovalenko, 1983).

The considerable scientific potential of nut crops was not practically exploited in the Soviet period. More than 80% of fruit bearing trees are concentrated in home gardens (the walnut more than 90%) with the exception of old plantations of hazel in Sheki-Zakataly zone (Azerbaijan) and several commercial orchards in the Crimea. Besides this, the walnut is represented in forests and home gardens generally as seedlings that, as a rule, are low yielding, with the nuts of poor quality.

The main potentials for nut production increase are in the setting-up of plantations in the most favourable zones, fast propagation of plant material by budding and grafting, orchard establishment of highly productive and early ripening commercial cultivars, high density planting, proper choice of pollinators, utilisation of scientific recommendations, etc.

On the basis of folk knowledge the most promising zones for walnut growing are: the Crimea, Kherson, Nikolaev, the Transcarpathian, Ivano-Franko, Chernovitsy and Odessa regions in the Ukraine; the south areas of Krasnodar Territory, submontane districts of Stavropol territory in Russia; the south and west areas of Moldavia; the Nakhichevan and several other regions of Azerbaijan, most regions of Georgia. In all these places it is recommended to establish highly intensive commercial orchards on small plots.

§ Member, WANATCA

In the Central Asian part of the former USSR the most favourable areas for the walnut are the southern districts of the Chimkent Region in Kazakhstan; the areas of Fergana Valley, submontane districts of Tashkent, the Surkhan Darya, Samarkand and the Kashka Darya Regions of Uzbekistan. In the territory of Tajikistan the walnut can be cultivated in practically all regions, besides the highlands of the Badakhshan Mountains. Kirgizia is the sole corner of the world where to this day wild nut forests, including walnut trees, remain. The major tracts of forest occupy 25 500 hectares in Osh region on the south west, south and south east slopes of the Fergana and Chatkal ranges. All yearly productive and twice flowering forms of walnut, that begin to produce nuts at the age of 2-3 years, were discovered here. This territory and the small plot near the south west coast of the Issyk Kullake are the most promising areas for the establishment of new walnut orchards.

The organisation of large scale commercial pistachio plantations in Turkmenistan is more promising on the basis of the Kushka forest plantings. New pistachio orchards may be planted on moderate irrigated unsalted soils in Mary, Tedzhen and Kara-Kala zones.

Commercial hazel growing would be concentrated in the Transcaucasus and in several areas of Russian North Caucasus (Yadrov, 1989).

Nut crops require more attention in collective and home gardens than in great tracts of walnut, hazel and pistachio in natural habitats, where nut productivity is low and unstable.

So Russia and the former republics of the former USSR have the real potential for a considerable increase in nut production.

The Walnut

The walnut (*Juglans regia* L.) belongs to the family Juglandaceae. The tree is vigorous, up to 20 m in height and 2 m in diameter. There is a high level of correlation between the diameter of vertical projection of tree crown and trunk height: 0.93 ± 0.01 (Nikitsky, 1970). The life span in its natural habitat may be 400 years or more.

The leaves of the walnut possess phytoncides. Protozoa die in 12 - 18 seconds, when they are placed with walnut leaves. Leaves contain vitamins C, B, P and E as well as ether oils (0.012-0.029%), gallic acid, inulin, inositol (muscular sugar), the alkaloid juglandin and mineral salts.

Walnut pollen is very nutritious. It contains proteins (23.15%), sugars (13.72%), cellulose (38.60%), water (3.90%) and ash (3.07%) (Vinogradova, 1966). Therefore, the pollen attracts an enormous quantity of bees during the blooming period.

The fleshy inner tissue of the pericarp contains tanning matters: tannins, dyeing source, the alkaloid juglone ($C_{10}H_6O_3$) and naphthaquinone. This tissue is very rich in Vitamin C (ascorbic acid) and Vitamin P (rutin) when the fruits are immature.

The walnut surpasses all well known vitamin plants (lemon, dogthorn, blackcurrant, etc) by the content of Vitamin C in the young fruits. Therefore, the immature fruits of the walnut

are used in order to manufacture Vitamin C as well as for preparation of jam and vitaminised wines.

In the past, the walnut shell was used widely for the manufacture of dynamite by virtue of its high cellulose content.

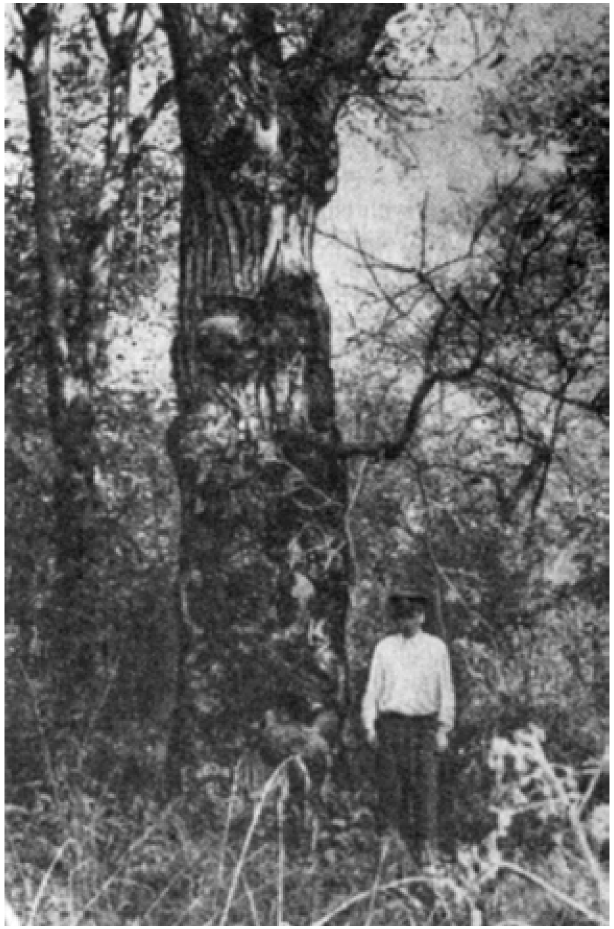
The kernel contains about 65% fat oils, 17% protein, 16% carbohydrates. The calorific value of the kernel is 7 times more than the calorific value of an equal quantity of beef.

Walnut oil is a valuable dietary product, similar to maize or sesame oils. Walnut protein surpasses the protein of hens' eggs by the content of lysine (6.2 g/100 g and 4.9 g/100 g respectively) (Grancharov, 1971).

Usually, walnut trees begin to produce fruit at the age of 7-10 years. Forms have now been discovered that can produce fruit at the age of 3-4 years and even 1 year (Cultivar 'Ideal').

What is the difference between early fruit producing and normal forms? Some of the seedlings, at the age of 1 year, bloom in August after the end of stem growth in height and establishment of fruit buds. In the second year sometimes they form not only female but male inflorescences (the catkins), too. Another feature is the secondary blooming, when complex hermaphrodite inflorescences are formed. Pistillate flowers are placed in the lower part and staminate flowers in the upper part of the inflorescence. The self pollination inside the inflorescence occurs at simultaneous blooming.

The secondary blooming begins 8- 12 days after the end of spring blooming. It can continue up to August. As a rule, such trees are significantly less vigorous. For example, in favourable


Ancient wild walnut in the Dashmansk Forest, Kirov Region.

conditions they reach not more than 8 m in height at the age of 50 years.

Unfortunately such valuable forms are short-lived: they begin to fruit early and die early. The trees of the most productive yearly fruited forms yield up to 35 kg at the age of 12 years, while the maximum yield of the common-type walnut is not more than 7 kg per tree of the same , age.

The fruits after the first (normal) blooming mature at the end of September and after the second blooming at the end of October. The nuts originating from the secondary flowers are small (4 g). When secondary blooming is late (June-July) most of the nuts are unripe.

In the southern zone walnuts bear every year with peak yielding at 50-100 years. In Uzbekistan the average yield per tree reaches 73-125 kg and per old tree with large crown 300- 500 kg (Rovsky, 1964).

A necessary condition for good growth of the walnut is sufficient moisture of the soil. Both excessively wet, boggy soil and very dry, saline soil are unsuitable for this crop.

In comparison with other species of *Juglans*, the walnut is the most drought and heat resistant. In spite of this fact, it is recommended to use irrigation. For example, in Moldavia they usually apply 2 500-3 000 m^3 of water per hectare during the season.

The walnut is a heat loving plant. However, this characteristic undergoes considerable changes in its introduction to the European part of the former USSR. So in the southern and southwestern regions of the Ukraine the walnut adapts easily to the frosts of -30°C and even to -40 °C and can stand them without significant damage.

This phenomenon is connected with good preparation for winter, as the shoots have finished their growth in the middle of July and are lignified in the beginning of Autumn. The fruit ripening and fall of the leaves occur at the same time (September - early October). Thus,

Some Russian walnut varieties. Left: Fast-growing Papershell; right: Dessertnyi.

the rhythm of the walnut's development helps it to adapt to winter conditions. For example, in Uzbekistan the damage to first year shoots begins at only a temperature of -27 to -28°C.

As a result of breeding, the walnut crop extends north and reaches the Voronezh, Belgorod and Bryansk regions of Russia. Hardy trees that produce fruit in Moscow are obtained by selection from seedlings of different origin. The most frost-resistant progeny was obtained from seeds collected in the Kirovograd region of the Ukraine and in Dagestan.

According to N.I. Vavilov (1935), the three centres of natural walnut growing are China, Central Asia and Asia Minor.

From west to east in Eurasia the habitat of walnut includes the mountain forests of Yugoslavia, Hungary, Rumania, Bulgaria and Greece. Towards the east it naturally grows in Turkey, in the states of the Transcaucasus (Armenia, Azerbaijan, Georgia), in Iran, Afghanistan, in the states of central Asia (Kazakhstan, Kirgizia, Tajikistan, Uzbekistan), in the north of India, the Himalayas and in mountainous China.

There are more than 66 000 ha of natural walnut woodlands in the forests of the former Soviet Union. In Armenia the walnut grows widely in small groves. In Azerbaijan natural walnut forests occupy several hundred hectares and are represented in isolated groves. Average tree age in these forests is about 180 years. Their height reaches up to 36 m and the diameter of the trunk to 80 cm. The forests of South Russia (Tabasaran area in Dagestan) number up to 200 000 long-lived trees at the age of 300-400 years, which are 30 m in height and 2 m in diameter (Osmanov, 1975).

Natural walnut forests are found in all Central Asiatic states (former republics of the former USSR) and the most of all in Kirgizia and Tajikistan. In the mountains of south Kirgizia the walnut rises to an altitude of 2300 m. Here the area of walnut forests is equal to 25 500 ha (Vinogradov, 1971).

According to A.V. Gursky (1957) the walnut in mountainous Badakhshan rises up the Pyandzh river to an altitude of 2400 m. In this area about 10 000 mature trees with heights up to 30 m with diameters up to 3 m were observed. The crown of these gigantic trees is about 50m and the yield reaches 300-500 kg. In Tajikistan there are 8 000 ha of walnut forests. Most walnut forest remaining (about 2 600 ha) are concentrated in central and western regions at an altitude of 3000 m (Zapryagaeva, 1965).

In Uzbekistan the walnut grows naturally in the Bostandyk area on the western slopes of the Tien Shan ridge and rises up to an altitude of 2 000 m. In Kazakhstan the walnut is spread in the wild only in areas adjacent to Bostandyk. In Turkmenistan the remainders of walnut forests are known in the mountains of west Kopetdag.

In Russia this crop is widely distributed in the Rostov region, in Stavropol and Krasnodar territories, and the republics of the north Caucasus. On a lesser scale the walnut is cultivated in the Volgograd and Astrakhan regions; towards the north it is in the Belgorod, Kursk and Voronezh regions.

In the Rostov region large walnut orchards were planted in state and collective farms in an area of 2000 ha. The same area was occupied in forestry. The Rostov Botanical Garden rendered great assistance in walnut distribution.

Unique walnut geographic collections were established in the experimental farm "Persianovka" of the Novocherkassk Engineer-Land Reclamation Institute. These collections allowed the selections of the best forms by winter hardiness, productivity and fruit quality.

The walnut is widely distributed in Krasnodar territory, especially in the forests and around the ancient settlements in the Adigei Republic.

In the forests of the Kabardino-Balkarian Republic, commercial plantations of walnut were established in an area of 2000 ha. Side by side with the seedling plantations, growers began to establish walnut orchards by grafted plants (Chebotarev, 1971). Early in the 1960s there were more than 500 000 trees in the orchards of state and collective farms in this republic (Kairov, 1964). New walnut plantations were established on several tens of thousands of hectares in Dagestan (especially in the Tabasaran area), North Ossetia, Chechnya and Ingushetia.

Thus the regions of the North Caucasus are the most promising zone for commercial walnut crops in the Russian Federation.

In the Ukraine the walnut appeared in the 10th century owing to close relationships with the Byzantine Empire. There are many old trees at the age of 300 years or more in the west and south west parts of the country. Most frequently, the walnut may be found in oak and beech forests.

The walnut crop in the Crimea was well known long before the birth of Christ. Here there remain centuries old trees yielding 200-300 kg of nuts and many late blooming forms were selected.

In Moldavia, walnuts number more than 1 000 000 trees. These are the largest walnut orchards in the USSR; "Kalarashsky" - 50 ha, "Kodru" - 70 ha and 24 other orchards with areas of 20-25 ha each (Tsurkan, 1969; Korableva, 1975; Rud, Zhadan, 1974).

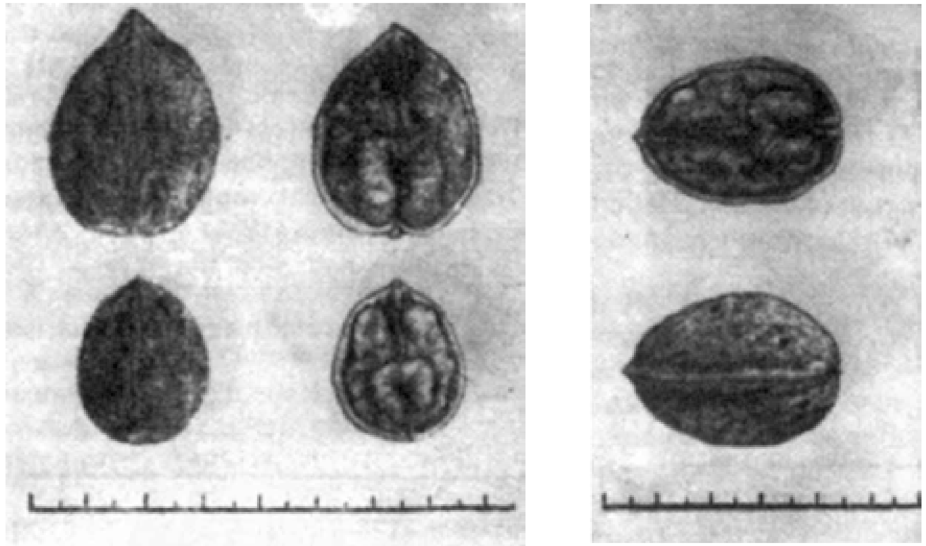
The walnut is a very ancient crop in Georgia. This nut takes an important place in the daily national cuisine. The long-lived trees testify to the antiquity of this crop. For example, a 700 year old tree (by other data 1 000 years) is known near Martkobi village (Kanchaveli, 1968).

Among the research institutions of the central Asiatic states the most intensive scientific investigations were done in the south Kirgiz Forest Research Station (Jalal-Abad) where about 300 improved forms were selected (Shevchenko, 1970).

There are not many walnut cultivars in the Official Plant Variety Registers in the states of the former USSR. The most interesting cultivars from these Registers are:

Dessertny

A chance seedling that was discovered near Krasnodar. The tree is winter hardy. Fruiting is in early September. The nut is medium in size (11.3 g), uniform, elongate-ovate, without ribs. The shell is thin, smooth. The kernel separates from the shell easily. The weight of the kernel averages about 48% of the total weight of the nut. The quality of the kernel is high. The fat content averages 60.6%, and protein 25.75%. Average yield is about 7 tonnes / ha at the age of 35-37 years. This cultivar is relatively resistant to pests and diseases. It is recommended for commercial growing in Krasnodar Territory.



Russian walnut varieties: Urozhainy (left); Tonkokoryi (right).

Ideal

This cultivar was developed by Bostandyk Branch of RR Shreder Uzbek Research Institute of Fruit Growing, Viticulture and Wine Making. The tree is winter hardy and small in size (not more than 8 m in height). The fruits are in clusters of 1-5. The nut is medium in size (10.2 g), flat-roundish. The shell is thin, wrinkled. The kernel separates well from the shell. The kernel averages about 50.8% of the total weight of the nut. The fat content in the kernel is 67.1 %. This cultivar is distinguished by exceptionally early fruit bearing (begins to produce fruits in the first year after planting), the secondary blooming and resistance to spring frosts. The tree produces average yields of about 12 kg at 9 years or 1.0-3.3 tonnes/ha. The cultivar is relatively resistant to diseases and partially tolerant to codling moth and leafroller. It is recommended for commercial growing in Uzbekistan.

Krasnodarsky

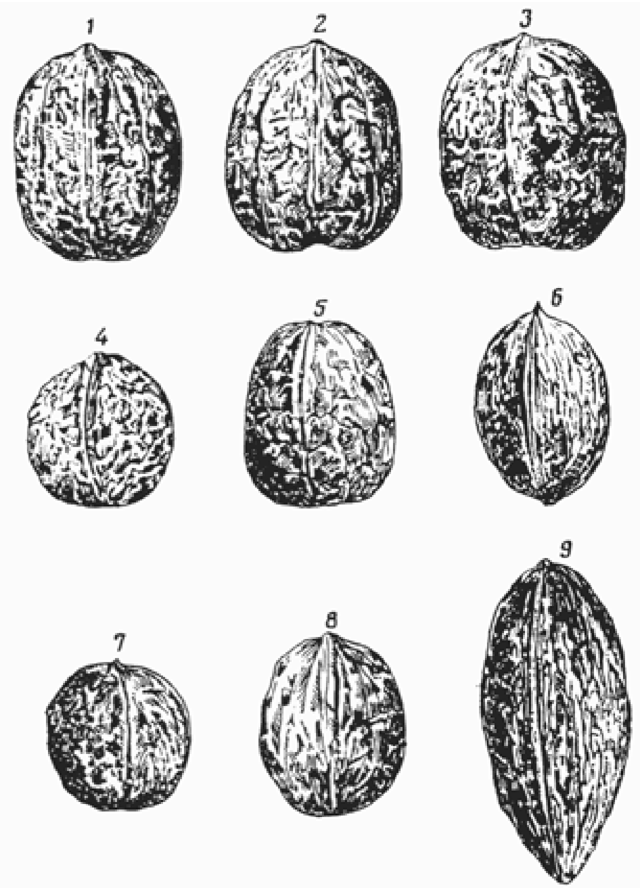
This cultivar is distinguished by high winter hardiness. The fruits ripen late in the season. The tree is vigorous, yielding up to 1.3 tonnes / ha at I 1-14 years. The nut is medium in size (11.8 g), uniform, cylindrical in shape, with great ribs. The shell is of medium thickness. The kernel separates from the shell easily. The kernel averages about 47.2% of the total weight of the nut. The fat content is 71.3%. The cultivar is relatively resistant to pests and diseases. It is recommended for commercial growing in Krasnodar Territory.

Maslyanichny

The tree of this cultivar is large in size, vigorous and hardy. The fruits ripen in late September. The nut is large (15.4 g), and separates from the shell easily. The kernel averages 52.4% of the weight of the nut. Fat content is 74.4%. The average yield is about 8.6 tonnes / ha at the age of 20-22. The cultivar is relatively resistant to pests and diseases. It is recommended for commercial growing in Krasnodar Territory.

Urozhainy

This tree is large in size, hardy. The fruits ripen at the end of September. The nut is medium in size (10.7 g), smooth. The kernel separates from the shell easily. The kernel weighs on average 57.0% of the nut. The fat content is 72.8%. Average yield is about 17 tonnes / ha. The tree bears heavily and regularly. This cultivar is relatively resistant to pests and diseases. It is recommended for commercial growing in Krasnodar Territory.



Some French walnut varieties. No. 9 is 'Barter'

Yubileiny

This cultivar was developed by Botadyk Branch of RR Shreder Uzbek Research Institute of Fruit Growing, Viticulture and Wine Making. It is a chance seedling of the local walnut. The tree is hardy and vigorous. The fruits ripen in midseason. Average yield is 2.8 tonnes / ha at 11 years. The nut is large (14.2 g), flat to round. The shell is thin and wrinkled. The kernel separates from the shell easily. The kernel weighs on average 50.24% of the nut. The fat content is 69.3%. This cultivar is relatively resistant to mites and leafroller and moderately tolerant to codling moth and *Marssonina* leaf spot. It is recommended for commercial growing in Uzbekistan.

Soviet breeders discovered and described many forms with good fruit quality, resistance to low and high temperatures, diseases and pests. For convenience, all the diversity of forms were classified into several nominal botanical varieties: 1. the large fruited; 2. dessert thin shelled; 3. the almond-like; 4. the clustered; 5. the late blooming; 6. the hard-shell (Shchepot'ev, 1978).

The large fruited cultivars belong to the botanical variety *Juglans regia* L. var. *macrocarpa* DC. Such forms are widely distributed both in orchards and in natural habitats. Their main defect is the puny kernel and inferior per cent of seed germination. Therefore, in general, they have ornamental value and they are good for breeding of large fruited cultivars. This group includes such commercial and promising cultivars as: Urozhainy, Dessertnyi, Maslyanichny, Krasnodarsky, Uchkhoz Kuban, Krasnodarsky Yubileiny, Krasnodarsky Samoplodny.

The dessert thin shelled cultivars belong to the botanical variety *Juglans regia* L. var. *tenera* DC. The fruits of this group have such a thin shell that they can be damaged by birds. The nuts have a higher oil content but produce lower yields than cultivars of other groups. The existence of thin shelled and naked fruited forms has been known for a long time. This type of nut is called "khcheni" in Armenia and "kagyzy" in Azerbaijan. The Russian scientist H. Steven, who was the founder of the Nikita Botanical Garden, described for the Crimea the naked fruited form, calling it "skinless". This group contains several commercial cultivars: Shkolny, Yubileiny, Tonkoskorlupy.

To the almond-like group belong the forms with fruit that have very narrow ends (similar to the almond). They are a member of the botanical variety *J. regia* L. var *bartherina* DC. In this group there are no commercial cultivars.

The clustered cultivars belong to the botanical variety *J. regia* L. var. *racemosa* DC. This form is distinguished by multi flowered inflorescences. 33 cultivars with clusters are known. The main commercial cultivars of this group are Gronovy and Ideal.

The late blooming cultivars form a very important group that belongs to the botanical variety *J. regia* L. var. *serofina* DC. This group does not include any commercial cultivars, but it is very rich in promising forms. In the Crimea such forms begin to bloom late in May or early in June, whereas normally walnut blossom in late April.

The hardshell cultivars have a shell that is difficult to crack and to extract the kernel. But as a rule many of these cultivars are distinguished by interesting properties. They are characterised by fast growth, resistance to disease, pests and winter frost. Therefore the hardshell cultivars are very valuable for acclimatisation of the walnut towards the north, for breeding new winter hardy cultivars and like rootstocks. This group belongs to the botanical variety *J. regia* L. var. *dura* DC.

Until now walnuts have been propagated mainly by sowing nuts from the best trees, as it is considered that the walnut reproduces its characteristics well enough from seed. But it is inexact and therefore this method may be used only for breeding, afforestation of slopes and plantings of shelterbelt forests. For planned orchards it is necessary to use only grafted plants. Such trees begin to produce earlier and are more uniform in size than seedlings.

Ring budding is used most frequently among the methods of vegetative propagation. This operation is made late in summer or in spring. Patch budding, spring bark grafting, cleft or shoulder grafting and grafting into the root crown are also widely used. The best results are obtained by semi-ring budding, when 75-80% of the buds sprout at the 20-25th day. This method allows the use of mature cuttings of any diameter. Good results are obtained by patch budding too.

In central Asia the walnut is propagated mainly by budding in June to July. In this short period it is impossible to produce a large quantity of plant material, but the output of budding plants is high (70-90%). The bud of the scion must be at ground level, then the bud is covered by sawdust in order to prevent sun burn when it sprouts.

A machine grafting method was highly developed in Moldavia (Bradu et al, 1972; Tsurkan, Chebotar, 1973). The machine MEKG-3 calibrates the cuttings of scion and rootstocks in diameter (10 - 160 mm). After that the machine PS-3 grafts automatically. Plants that were grafted by means of this machine are equal to those hand grafted, on callus development and growth in the nursery.

Tsurkan and Chebotar (1973) developed bench grafting modification for room conditions. They used the grafting machine MP-7. The best period for this method of grafting is from the 20 December to 15 March. A 3 person team can graft I1200 - 1500 plants in 8 hours. When grafting is done by hand the productivity is not more than 120 -150 plants in the same time.

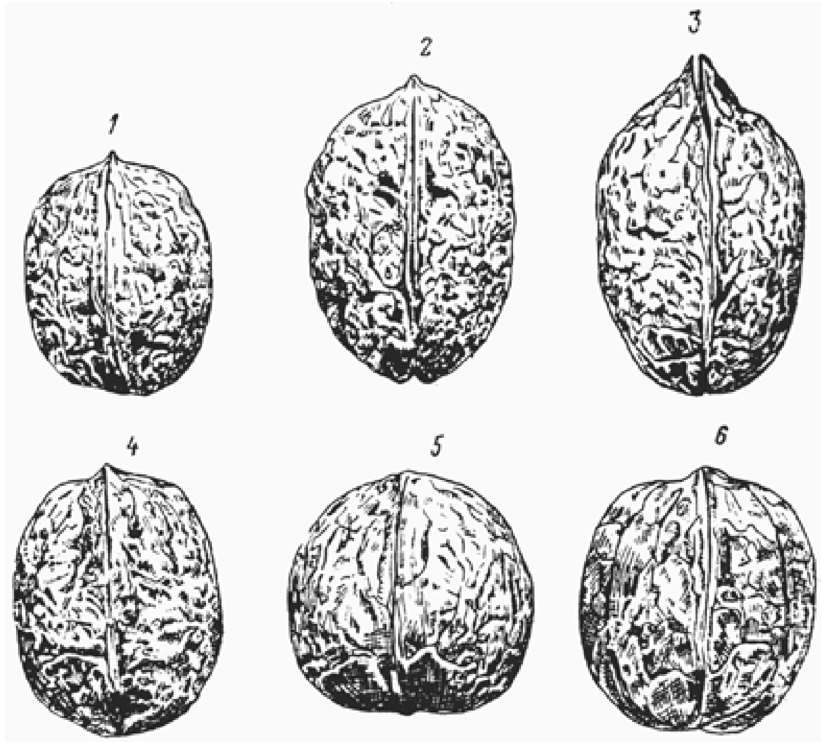
Walnut trees should be spaced at 12 x 12 or 16 x 16 m (40 - 70 trees per hectare). Trees of early producing cultivars that have a short life can be planted at 6 - 8 x 6 - 8 m. On terraces spacing of 10 x 10 or 12 x 12 m is recommended.

In young irrigated orchards the soil of the interrows is used for the sowing of legumes, vegetable and melon crops. In arid zones the soil of the interrows lies fallow and the soil under the trees is mulched.

The most advisable rates of fertiliser are N60:P60:K60.

Walnuts are usually trained to a modified or central leader with six or eight main laterals distributed up and down and around the main stem. After this minimal training, very little pruning is done.

Trees begin to produce in the 5th to 8th year after planting. Nuts are picked by hand or machine. Mechanised harvest of nuts from trees up to 6 m high may be carried out using machine VSO-25, which works with the tractor T-25, the nut combine of Azerbaijan Research Institute of Agricultural Engineering and Electrification, the fruit vibrator of the Central Asiatic Research Institute of Forestry (Tashkent) are used. The nut harvester MPU-3M was



Californian walnut varieties

developed in 1986 by Gorsky Agricultural Institute (Vladikavkaz). This machine can harvest 96 - 98% of fruit at the stage when 50% of them are ripe.

Thus it is now possible to mechanise nearly all the processes in walnut growing.

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(To be continued ...)

[Illustrations reproduced from Shchepot'ev (1978)]

Submission of Articles

The WANATCA Yearbook is devoted to useful longer articles, likely to have continuing reference value, about any aspects of nuts, fruits, and other tree or perennial crops.

Articles would be gladly received from any source - there is no requirement to be a member of WANATCA. If the text is available on a computer or word-processor disc, this is greatly appreciated. Text and enquiries can also be sent by fax or e-mail.

The WANATCA Yearbook is produced at the Tree Crops Centre, Perth, for the West Australian Nut & Tree Crop Association Inc.

Please send articles or enquiries to:

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Quandong has details of forthcoming Association meetings, events, and field trips, book reviews, news items of interest, reprints of short articles drawn from world-wide sources, members' comments and queries, and notes on sources of trees, seed, materials and services.

The **WANATCA Yearbook** is our major research publication, with original articles of permanent interest. It is indexed as part of the global coverage of the U.S.-based Biological Abstracts Service.

The **Australasian Tree Crops Sourcebook (ATCROS)** is our major reference work, containing regularly-updated tables of all sorts of useful material about tree crops (common and botanical names, growing conditions, recommended areas etc.), membership lists, lists of useful tree crop organizations world-wide, and a commercial-sources list, acting as a Directory of Tree Crop Services for the whole of Australia, New Zealand, and adjacent areas. Relevant services (e.g. seed suppliers) are listed worldwide.

There are various classes of **membership**. The standard grade is **Full Membership**. It is open to individuals, families, and any form of organization (companies, research units, libraries, etc.). New Full Members will be accepted on application; no entrance fee is charged. **Student Membership** is a concessional rate for current-year students unable to pay full rate. **Sustaining Membership** is a special grade for those supporting the aims of the Association who are able to give extra financial help to achieve those aims. **Life Membership** is available to existing individual members of at least 3 years standing who wish to commute all future payments into a single sum. **Overseas Members** are welcomed and pay no more, although they may optionally receive publications by air-mail for a small premium.

All subscriptions (except for Life Members) run for the calendar year; new members may join at any time, and receive all publications for the year. After October 1, new members may elect to start their subscription with the following year; they will have membership benefits for the rest of the current year, free of charge, but not the current year's *Yearbook* or *Sourcebook*.

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