that are true-to-type. These can either be grown in a stock ground or under protection, as the best rooting material comes from actively growing stock. The longer the delay in taking the cuttings, the harder they become to root.

Preparation. The cuttings are made 75 to 100 mm in length and the leaves are trimmed to reduce water loss and to help to get more into a given area. Then they are given a slit wound at the base, which is done by drawing the knife point down the stem on the lower 15 mm when using liquid hormones. Use a slice wound when using powdered hormones. The hormones used depend on the timing of the propagation. For early cuttings taken in June Seradix 2 is ideal. In July/August the material is hardening up so use a liquid hormone (0.5% IBA) allowing it to dry before insertion.

It may be possible to use an acetone dip and then dip into Seradix 2 for the later cuttings as it may be easier to obtain acetone than liquid IBA.

Insertion. This is into a 50/50 peat-sand compost using either seed trays or Japanese paper pots. The latter gave little root disturbance which is good as the cuttings are adversely affected by root disturbance when they are potted on.

Aftercare. The cuttings are placed under mist and are watered in with Benlate solution as this helps to counteract disease problems.

Over wintering. Losses can occur since the cuttings have used up most of its food reserves in rooting and the buds may not be able to break dormancy the following spring. This is a problem with most members of the family Hamamelidaceae, so the aim is to induce 50 to 75 mm of new growth before winter.

If rooted early enough the cuttings can be potted so as to get new growth on them before winter or, if they are late, they are best left in trays until the following spring when they are potted up. The rooted cuttings are housed for the winter. Rooting will be well advanced in 6 to 10 weeks after insertion, with a take of 70 to 90%, on the average.

SUCCESSES AND FAILURES IN STARTING A TREE SEEDLING NURSERY

STEWART ST. JOHN

Kirby Bellars, Melton Mowbray
Leicestershire, England

Reasons for choosing to start a nursery of this type:

a) Limited capital required
b) Plenty of scope competing with imports
c) Cheap source of seed — locally collected
d) Working alongside knowledgeable people on the subject
e) Interesting and challenging subject in itself
f) Local outlets

Type of plants to be produced

a) One-year-old lining-out stock
b) Understocks for grafting and budding
c) Hedging material
d) Potted stocks for grafting — birch, beech, *Robinia*, yew.

Choosing a site. One should choose a site with a light to medium well-drained soil. My progress has been stifled by having to start on sites that held these drawbacks:

Half-acre plot right next to the river: subject to flooding and frosts. Soil is fertile but heavy and difficult to work when wet.

Top of a hill: very exposed, cold site. Land is ridge and furrow, causing irregular soil depth; poor drainage and difficult to mechanize.

Seedlings in their first year benefit greatly from warmth. An ideal site would be well sheltered, especially from the southwest, flat or with a gentle, south facing slope. Soil ideally should be on the light to medium side and well drained. Good drainage is imperative as seeds about to germinate will not tolerate waterlogged conditions. The site should also be fenced against rabbits.

Growing system. Starting with 4′6″ beds (135cm), we found them too wide for easy working, weeding, thinning, etc. Now we use 4′ beds (120cm) and also increased path widths to 15″ (37cm) from 9″ (23cm). We prefer slightly raised beds (2″3″) as they are:

a) Marked out ready when raised
b) Drained in a wet spell
c) Less dry at the edges than higher beds
d) Less far to bend to when working

For undercutting it makes little difference if the beds are flat or raised.

Land Preparation. Prepare early where possible, especially for seed sown fresh. It can be difficult to get land cultivations done well on a small scale in an agricultural area. If breaking old pasture, treat for wireworm during pre-sowing cultivations. Sterilize with Basamid or Di Trapex but not too early or there may be reinfestation of weeds. Some seeds are sown straight after collection. These are the bulky to handle species.

Kitting up with tools and equipment. For one acre of seeds beds, one needs:

a) A good selection of hand tools.
b) A reliable sprayer. We started with knapsack, then a motorized knapsack, and now we use a tractor-mounted sprayer with a lance.
c) Gravity roller.
d) Protection material against birds and frost. This is the costliest single item other than land.

My view is that we must use frost protection where necessary as late frosts could wipe out the crop of some species. Frost protection material has a 10 year life and costs 25p per sq. metre over 10 years. It is then used as internal windbreak material, or for shade requiring plants. The area is divided into 6 to 8 bed bays. The natural windbreaks best for the perimeter are *Alnus incana*, *A. cordata* (semi-evergreen), willow, and *Prunus cerasifera*.

Seed collection, pre-treatment and sowing. During the first two years seed was 80% home collected but now we collect only 50% as a wider range of species is grown and many species fail to set seed in this country. Collecting in this country can be time consuming. Home collected seed is relatively cheap and can give better establishment or acclimatization. It can be collected in the right condition — fresh or green. Our business would have failed if we relied on imported seed only. There are problems of unreliable delivery — seed may be too late to treat if we order one year ahead, then the seed is older and less viable. It is expensive and quality is very variable. It is unknown how it was stored and usually there are full dormancy factors to overcome. Foreign seed-houses still do a good job, however, and we couldn't do without them and they offer a very good range of species. It is best to try as many different seed houses as possible. The Forestry Commission now offer a seed service and also gives information on seed treatments. More and more kinds of seeds require source certificate of origin, though not so many ornamentals require certificates.

Record good seed stands during the summer and seek permission to gather whether on private and or county council property. Cherries are gathered in July, rowans in August. The majority of seeds ripen in September or October but those of ash are not ready until November. Check all seed for viability before collecting. This is very important. Fresh seed is usually tested by cutting and examination. Imported seed can be subjected to the tetrazolium test or to a direct germination test. Large seeds can be checked by a flotation test. Collect seeds only from good, healthy well-shaped specimen trees. Don't mix

the progeny of the same species, as they can vary considerably, and keep records of all sources.

Fresh seed is always best; it is more vigorous, has less dormancy factors and a higher germination percentage.

I started by using open stratification bays. I mixed freshly collected seed with peat and grit and placed it in bays straight after collection. I soon ran into problems as seeds of many subjects decayed. Sycamore and Norway maple seed germinate in January after a mild spell, as they only require 4 to 6 weeks chilling. With this method some subjects like *Sorbus* seed gave about 10% germination. The majority had not received sufficient chilling in an English winter. I now only stratify seeds of a few species outside. These are *Acer campestre*, ash and hornbeam, picked green and sown in February or March before the radicle emerges.

I tried to reduce the amount of seed to be sown in spring of cherries, sycamores and Norway maples by sowing in autumn but had disastrous results, including damage done by mice. Only 2000 out of 20,000 cherry seeds germinated. Now I only sow large seeds (oaks and chestnuts) in autumn. If these dry out they quickly die. Norway maple and sycamore seeds are sown in March as there is still time for them to be chilled in the seedbed. I decided to try giving cold temperature treatments in a domestic refrigerator to subjects like *Sorbus intermedia*, *S. aria*, *S. aucuparia*, *Malus*, *Pyrus*, *Amelanchier*, and *Syringa* seeds. I started doing this on a trial and error basis and mixed clean samples of imbibed seed with 2 to 3 times their volume of moist peat or peat/grit, sealed them in polythene bags and placed them in a refrigerator at 2 to 4°C (36° to 39°F). Once per week the bags were opened and the seeds inspected for decay or drying and the mixture turned to allow exchange of air. Inspection will determine when many seed lots are nearing germination time as shown by radicle emergence. I found out how long a stratification time each species required by doing germination tests of 50 seeds each week. These were sown in small trays and the percentage germinated after so many weeks chilling was recorded on a graph. A peak of germination is reached after so many weeks. If a small sample batch is chilled 2 to 3 weeks before the main batch then sufficient time is available to see the length of time the sample batch requires. We then sow the main batch of seed. This system has given consistently good results.

Chilling times for seeds of some species are shown below:

Sorbus intermedia	18 weeks
Sorbus aria	16 weeks
Sorbus aucuparia	20-22 weeks

Malus pumila (Syn.: *M. communis*)	9-11 weeks
Pyrus communis	9-11 weeks
Nothofagus	6 weeks
Prunus avium	10-16 weeks
Tilia platyphyllos	up to 22 weeks

Using this system, a sowing programme can be worked out. Another useful factor, if the equipment is available, is to freeze seed ready for sowing if the sowing conditions aren't suitable or if the seed beds are not prepared. You may ask, why freeze the seed if it is already in a refrigerator. Well, even at 2°C (36°F) the seed, once dormancy has been broken, will start sprouting, but we can freeze down to −5°C (23°F) without detriment to the seed.

In April sow seeds of the cold stored subjects. In April/May sow seeds of birch, and alder, and in May/June, *Ailanthus, Cercis, Hibiscus, Catalpa* and *Robinia*. Seeds of species from temperate climates tend to have lengthy dormancies so that germination does not occur during mild winter spells with the seedlings being killed off by ensuing frosts. In north temperate regions, where winters remain extreme from autumn to spring, cold dormancy temperatures are relatively short because once the cold weather starts, there is no let up. The benefit of prechilling chilling until spring can be seen with coniferous subjects (softwoods), where seeds of some species require no chilling to germinate. However, if seed is pre-chilled, the amount of growth can be doubled in its first year. Try to collect seed before it is fully ripe. This reduces added dormancy factors such as hard seed coats and lengthy cold period requirements. With berried subjects, the longer the flesh is around the seed, the more dormant the seed becomes, so collect on the turn, crush the seed and immerse in water to ferment the flesh. After 3 to 5 days wash through a sieve immersed in water. Run off the water, dry the sample and remove chaff, then a count can be made by weight or volume. Seeds of hard seed-coated subjects require a warm period to break down the hard coat and, in nature, they get this in the summer. It may be necessary to supplement natural warmth in a cold summer by placing the seed in a warm place for a further period, e.g. in thorns and limes. When giving these treatments the seed must be in a moist medium. The use of concentrated H_2SO_4 is suitable for seeds of some hard coated subjects such as *Crataegus crus-galli*, rose achenes and *Hamamelis*. This is supplemented by a warm spell to break through the final stages of the seedcoat, then the chilling can be given. Many subjects just require a cold period. Some show epicotyl dormancy, e.g. *Viburnum lantana*, where the radicle emerges the first summer and the plumule the following one. Other kinds of seed require warm or cold water

soak for up to 24 hours and, with others, boiling water is added, as for *Robinia* and *Gleditsia* seed. When sowing, bulk up small seeds with sand or grit as this facilitates sowing evenly and helps seed to "run." Roll in the seed after sowing and cover with ¼" grit, then roll again.

Ideal germination conditions occur in April during showery weather. One may have to create this during dry spring. Sow too thickly rather than too thinly as one can always thin out, though this depends on the value of the seedlings. For the less hardy seeds, we cover with protection material over wire hoops. This material is later used for windbreaks.

Some seeds show polarity, e.g. sow horse chestnuts so that the brown scar faces downwards. Sown thus they should attain up to 90% straight stems and roots. *Castanea sativa* seed should be sown with the point downwards. Seed density is very important. A number of factors are concerned such as soil type for, if it is heavy, it can produce large plants. Density will also be governed by the quantity and ratio of supplementary feeding and by the type of plant required. For large one-year seedlings, I give 13 × 13cm 60/sq metre. For liner size of good quality I give 8 × 8cm 150/sq metre. It is easy to be greedy and produce dense seedbeds of thin drawn plants. Give a base dressing of 1 to 2oz superphosphate to the seedbed. Seedlings respond well to liquid feeding. We changed from potassium nitrate and urea to a proprietary brand which does not require dissolving in hot water. It is easy to put on too much nitrogen and spoil the crop. Always feed in balance, e.g. 1:2 N:K.

Thinning out is very important for good quality seedling crops. Skilled operators should be able to recognize runt seedlings if the beds are not thinned too early. They have thinner stems or are smaller plants. Spray every 7 to 10 days against usual pests (aphis, caterpillars). For powdery mildew on apples, pears, oaks, field maple, and thorns total coverage by high volume is best and alternate spray materials are used. Much effort should be taken in presentation of a saleable article. The young trees should be neatly bundled and well-graded.

Storage of seeds. Seeds that do not deteriorate when dry can be kept in a cool dry atmosphere. Some seeds heat up if stored too thickly, e.g. beech. These should be stored in not more than 6" layers and should be turned every few days. It is always worth bearing in mind that the larger seeds normally make the biggest plants.

Key to success on a small scale. Don't grow too many lines. It is better to grow a few well and in quantity. Use locally collected seed where possible. Choose a good site with abundant water supplies available.