The growth was so good up to this stage that it was decided to pot them on into half-gallon containers, and they were then stood in the open in the same area. When they were cleared from quarantine in November 1972, they were planted outside in a sheltered area.

Conclusions. The results of this venture were excellent, about 90% of the grafts being successful, although the *A. negundo* cultivars proved to be the most difficult. As far as the *A. pseudo-plantanus* cultivars were concerned there was no noticeable difference between those that were side-grafted and the few cleft grafts that were used.

We consider that the success can be attributed to the fact that the scions arrived in such an excellent condition from England and were immediately grafted onto vigorously growing stocks.

ASPECTS OF SEED SUPPLY AND GERMINATION PROBLEMS, SUCH AS DORMANCY, AND THEIR TREATMENTS

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One of the greatest disappointments in a nurseryman's experience, both economically and personally, is a failure in seeds germinating satisfactorily, especially if this failure occurs in a new and potentially interesting cultivar. This is even more so when expectations of a new or improved strain, resulting from a crossing personally initiated, fail due to the seeds to even germinate.

There are 4 basic factors that could cause poor or non-germination of seeds:

- (1) Was the seed viable prior to sowing?
- (2) Were dormancy factors taken into account?
- (3) Were the physical constituents of the seed bed at optimum levels?
- (4) Was there any evidence of pathogens, either externally or internally on the seed, in the germinating medium, or contained in the various ingredients added or surrounding the germinating medium at a later stage; for example, in the water or air?

Seed viability. Obviously it would be uneconomic to sow seed that does not even have the ability to germinate. Thus the first requirement becomes obvious. Will the seed grow if all other germi-

nation vagaries are discounted? Non-viability of seed can be due to a number of causes:

- (a) Genetical incompatibility, especially in either intergeneric crosses or in interspecies crosses. Generally seeds do not even form though seed pods may; seeds, if formed, are normally non-viable.
- (b) Lethal genetical characteristics occurring with, most frequently, selfed species or selfed hybrids, especially in crossed F₂ hybrids, although a fair proportion of seed might be viable from the same plant.
- (c) Pathological changes in the seed tissue damaging the embryo; these can be caused by either fungal, bacterial or virus attack.
- (d) Physical damage to the seed arising from extremes of temperature, insects, or spray damage; too high or too low moisture content or mechanised injury during harvesting or processing.
- (e) Premature seed collection before the embryo is sufficiently developed.

Of these, only the two genetical causes remain beyond practical control; the others can and should be overcome by using virus-free, clean, well-cared-for mother plants, and instituting a regular spray programme, using well-tried non-damaging sprays from spray equipment that has not been previously used for hormone weedicides. Correct timing in seed collection and perhaps most pertinently, exemplorary vermin-proof storage facilities with constant cool temperature and controllable humidity will also assist.

Establishing whether seeds are viable is simple in the case of most annuals and a number of perennial shrub and tree seeds. This is done by sowing them under optimal conditions, giving a test programme ranging up to two months when germination will be evident. However with seeds that have a suspected or known dormancy condition, using this method can be very time consuming, especially if the seed if finally proved non-viable. Possibly the most common method with seeds in this category is the tetrazolium or excised embryo test, which is beyond the capabilities of most nurserymen. So, in many cases, purchase of stock seeds from a reliable seed house is the most economical measure in growing standard lines from seed.

Dormancy. Once the seed has been established as viable the problem of seed dormancy may still occur. Dormancy is basically a method of plant adaption to its particular, often unique, natural environment to ensure species survival. A study of the plant's natural habitat with particular consideration being given to temperature fluctuation, seasonal rainfall, soil type, light quality and

quantity, forms of seed dispersion, can — in the broad sense — give the propagator a good idea of dormancy problems likely to be encountered. Knowing the problems, means the battle half won. Dormancy falls into various categories, which in some species may be overlapping:

- (a) Impermeable seed coats are generally due to waxes or other substances being part of the normal seed coat structure. This type of dormancy can further be divided into:
 - 1 Impermeability to water (e.g. in many legumes)
 - 2 Impermeability to oxygen (as in many grasses and composites)

Dormancy due to impermeability of the seed coat to either of the above may be overcome by scarification, either by mechanically abrading or cutting the surface coating, or by immersion in hot water, concentrated acid (usually sulphuric) or some other solvent such as ether. Should, however, impermeability occur due to water not reaching the true seed coat for some time — for instance, in seeds with a particularly hairy covering — soaking in water with detergent will often bring about seed hydration and ensure an even germination. Impermeability dormancy is broken in nature by either (or a combination of) freezing and thawing, decay of seed coats by bacteria or fungi, forest fires, and various enzymes in the digestive tracts of birds and animals.

- (b) Mechanically resistant seed coats. Another form of dormancy occurs where the seed coat is exceptionally strong and hard even though permeable to water and oxygen. The pressure of water inside the seed after a period of time, greatly reduces the water potential gradient, thus reducing the amount of water absorbed by inhibition or osmosis and whilst this state occurs, little or very sporadic germination will take place. However should the seeds dry out, dormancy is eliminated and normal germination proceeds when the seeds are exposed for the second time to wet conditions. This is common in Juniper seed and, in a number of nut species, this type of dormancy can be overcome by the methods mentioned above.
- (c) Rudimentary embryos occur in a number of plant species (e.g. orchid and ginkgo) where the seed is mature but the embryos are not. These embryos, in some cases, are nearly mature but in others, only a pre-embryo state exists. Breaking of dormancy in this case is purely a matter of time in waiting for the embryo to reach maturity. However, if the cross is particularly interesting or likely to be valuable, the embryo may be excised in the laboratory and grown under sterile conditions in nutrient agar, the nutrients depending on the stage the embryo's metabolic processes have reached.
 - (d) Dormant embryos. This form of dormancy affects many

temperate and cold zone plants, the embryos in this case being morphologically mature, but the embryos themselves remain dormant. This dormancy is most probably genetical in origin and possibly involves temperature, water, oxygen and light. Enzyme synthesis is involved which enables the embryo to germinate. Should any of these physical conditions, either singly or as a group go beyond optimum levels, then perhaps an enzyme inhibitor could be set up causing the seed to revert to a secondary dormancy. Seeds of plants in this catagory require a process of after-ripening at various temperatures.

Type 1 — This is typified by apples, peaches and other similar species, require moist-chilling to break dormancy; temperature levels of 2° + 5°C, in association with moisture levels sufficient to hydrate the seed, and ample aeration of the stratifying medium are required. Germination rates are generally inversely proportional within the temperature parameters.

The time required for moist-chilling has considerable variation with various species; most woody perennials require 1-3 months, others up to 6 months. Unfortunately, scarification, while decreasing germination time, may produce a dwarf stunted plant. Those of you who wish to try a fairly new technique to induce faster germination, could try scarification, allow a period of chilling — making sure that aeration is not inhibited — increasing the temperature slowly until germination is evident. When germination is established, increase the temperature to, say 30°C, giving a long or continuous photoperiod, with a minimum of 16 hours, followed by an application of GA3.

- **Type 2** Embryo dormancy: requires high temperature followed by low temperature; applicable to Lilium auratum, some viburnums, Fraxinus excelsior and Ilex spp., but in the latter two, seed coat inhibition, as mentioned in type 1, also occurs.
- Type 3 Low temperature, high temperature: Low temperature occurs in a number of temperate perennials and requires a season of cold, a season of heat, followed by a season of cold. These temperature fluctuations engender response in various sites within the embryo. Firstly, after-ripening of the radicle; secondly, radicle growth; thirdly, ripening of the epicotyl; then normal germination when the temperature is increased again.
- (e) Chemical inhibitors. These may occur anywhere within the seed or be absorbed by the seed from the external environment. These cover a wide range of chemicals ranging from alkaloids to common salt. This form of inhibition is generally broken by leaching the seed in water, or by soaking in a solution of agents known to decrease the inhibitory effects; for example, in seeds where high concentrations of abscisic acid occur, germination can be instituted by soaking in a GA₃ solution 100 mg to 1000 mg/l.

Another chemical germination inhibitor, coumarin, can be used on seeds that do not have a light requirement to induce a light requirement. Cold temperatures can also remove some forms of chemical inhibition by possibly slowing production of enzyme inhibitors and allowing normal development to proceed.

Some modern concepts in removing dormancy problems lie in the field of genetics whereby selective breeding programmes are instituted using low dormancy species crossed with high dormancy species. Offspring should have a dormancy period similar to the geometric neon between the parental dormancy periods.

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OBJECTIVES AND RESEARCH METHODS IN THE ROOTING OF APPLE CUTTINGS

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This paper is a progress report outlining research methods at Massey University being used in the study of the physiology of root initiation of cuttings. While this work is being conducted on apple rootstock hardwood cuttings, the methods used and perhaps the results obtained, will have relevance and application in the propagation of other plants by cuttings.

The prime objective of this research is to investigate why two cultivars of the same plant species, have a widely differing ability to form adventitious roots when treated and planted as cuttings. By using apple rootstocks there is the added advantage that if we can get cuttings of apple rootstocks to grow successfully, then it is a much easier and less laborious task than raising rootstocks by the traditional methods. Apple rootstocks are useful research plants for several reasons. Firstly, workers at East Malling have described a system of propagation of hardwood cuttings which has had some success. Also preliminary studies on rootstocks have resulted in obtaining two rootstocks, one which roots readily, the other one very poorly.