DORMANCY CONTROL IN MAGNOLIA SEED GERMINATION

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This project was undertaken to elucidate and confirm the pattern of seed dormancy and the conditions required to achieve an optimal germination in a range of the early flowering Asiatic magnolias. It constitutes the primary phase in a series of observations which are being carried out to develop a productive and reliable schedule for magnolia seedling production. The programme is required to produce seedling rootstocks of suitable size, at a relevant season, for budding or grafting with scions of selected clones or named cultivars of the early flowering, "tree" type, Asiatic magnolias.

It is necessary to propagate these plants vegetatively so that flowering specimens can be produced in an acceptable time span. Seedlings of some species (e.g. *Magnolia campbellii*) can exhibit juvenile phases of up to 40 years and even then flower quality is not guaranteed. Stem cutting propagation is not reliably documented and what little information is available points to a poor rooting capacity of the stem material and the slow initial growth rates of rooted cuttings. Thus grafting becomes the only reasonable, commercially acceptable and economic method of propagation, especially in those cases where limited stem material has to be used productively. It is possible that increased supplies of suitable stem material, produced as a result of this exercise, will lead to a study of propagation by stem cuttings.

As would be anticipated, in any grafting exercise, it would be prudent, at least initially, to use seedlings of the same species as a rootstock for a particular scion—or at least a species or a hybrid which is both closely related and of the same vigour and growth pattern. It also seems wise to determine graft compatibilities, scion growth rates and tree performance using a range of rootstocks for each scion cultivar, in the event that seed of any subject became unavailable and the range of rootstocks thus becomes restricted. What evidence is currently available suggests that there is a wide ranging intercompatibility among most temperate species and hybrids in the genus *Magnolia*—whether they are evergreen or deciduous. There is little documented evidence, however, on the subsequent performance of various stock/scion combinations, the only reports being restricted to observations on the need to use stocks and scions of similar girth development and rates of growth. It may also become apparent that certain combinations of stock and scion will induce a more precocious flower production.

Magnolia seeds are produced in a cone-like fruit of coalescent, nominally two-seeded, fleshy follicles. At the time of flowering, pollination and subsequent fertilisation is often erratic so that only a limited number of seeds may develop and a contorted cone is produced. Those seeds which do develop nevertheless normally exhibit good viability. Pollination may be limited by the availability of certain insects and successful fertilisation may be limited by insufficiently warm temperature at the critical period. The seeds are liberated from the cone in the late summer to early fall period. As a result of drying the follicles will split longitudinally along their outer edge and eventually the seeds fall free. In the initial dispersal stage they are retained and hang temporarily from the follicle by a thread-like, mucilagenous "suspensor".

Collection of the seeds is achieved by removing the fruits from the tree just at the stage when the follicles begin to split and the scarlet/orange/red seeds can just be seen. The fruits are then air-dried in a warm, dry environment until the seeds can be shaken free. It is not advisable to remove the fruits from the tree until this stage has been reached, as immature cones may not dehisce satisfactorily. The drying process should not be prolonged beyond the stage that is necessary to achieve separation of the seeds, as excessive drying may lead to a loss of viability in the seed sample.

The seeds are relatively large, and when fresh are fleshy and sticky. Structurally the seed consists of a minute embryo which is embedded in the base of the endosperm and this, in turn, is retained by a thin, skin-like internal seedcoat. This part of the seed is surrounded by an inner hard seedcoat which itself is embedded in a thick, oily, fleshy, outer seedcoat. This outer seedcoat provides the attraction for birds or small rodents and so ensures dispersal. It also protects the seed, in the short term, against desiccation and prevents imbibition. The inner, hard-textured seedcoat protects the seed on its passage through the digestive tract of the animal. Despite the hardness of this seedcoat this factor is not a constraint to imbibition nor conversely does it protect the seed against water loss.

The embryo is immature (i.e. it is differentiated into radicle and plumule but is as yet very small); rarely it is more than one sixth the length of the seed.

The endosperm is large and virtually fills the seed: the food reserve is stored as fats and oils and is consequently very susceptible to inactivation as a result of drying. Long term storage at high temperatures can be deleterious—as a result of the materials becoming rancid.

Observations on the storage of *Magnolia macrophylla* seeds (7) have indicated that the extracted and cleaned seeds can be stored without any significant loss of viability, under water—conserving conditions and at room temperature, for periods of up to 180 days.

This particular study was not an original exercise but was prompted by the results of trials conducted on *Magnolia virginiana* by Del Tredici (2) of the Arnold Arboretum. His observations had determined the basic pattern of dormancy, its treatment and the conditions necessary to encourage germination for this species. He also reported, from more limited evidence, that very similar patterns were exhibited by other North American species. It was, therefore, necessary to determine whether the Asiatic species behaved in a similar pattern.

The successful seed germination of temperate subjects having seeds with an immature embryo will conventionally depend upon the following sequence—maturation of the embryo, the removal of embryo dormancy controls, and the provision of an environment favouring germination.

The normal expectation is that embryo maturation will be achieved by warm stratification of the imbibed seed, that this should be followed by a period of chilling to overcome the dormancy factors in the matured embryo and then the subsequent exposure of the seed to a sufficiently warm temperature that germination and emergence is encouraged—a sequence that is typically encountered for the immature embryos of *Fraxinus excelsior* and *F. nigra* and the rudimentary embryos of *Ilex opaca* and *I. aquifolium*.

The sequence of treatments which are required to achieve germination in the genus *Magnolia* however is exceptional, and it is not one which is a normally recognised category in the usually proposed systems for the classification of seed dormancy. In the case of magnolias (and certain other *Magnoliaceae*), the embryo requires a period of chilling in order to remove the dormancy controls which are apparently already present and effective in this immature condition (thus preventing embryo maturation) as an initial treatment; subsequent exposure to warm temperature causes the embryo to increase to mature size and as a result of the uninterrupted continuation of this expansion and development the seedcoat ruptures and this leads into emergence (i.e. germination) without delay.

The practicalities involved in the treatment of the seed, in order to encourage controlled germination, begin with the extraction of the seed from its outer fleshy seedcoat. This can most readily be achieved by maceration of the seeds in warm water followed by a short period of fermentation (24 to 48 hrs); subsequent maceration and cleaning in fresh water should provide a reasonably clean sample. A final rinse using a conventional liquid detergent removes any oily film remaining on the surface of the seed. The seed in its bony seedcoat can then be surface dried and is ready for assessment and further treatment. The seed should then be treated without delay (i.e. stored or subjected to its germination pretreatments) to prevent any internal water loss from the imbibed embryo and food reserve.

When required, the seed sample is stratified using a moist extending medium—at about four volumes of medium to one volume of seed—and is sealed in a suitable container (a thin grade of polythene bag). This labelled container is then refrigerated at 1 to 3°C in order to achieve the chilling effect necessary to overcome the embryo dormancy. The majority of the surveyed literature usually makes vague and blanket recommendations for long periods of stratification in the range of 90 to 180 days. All of the species observed, however, exhibited some radicle emergence on exposure to warmth after 42 days of chilling, with a maximum response being achieved after 56 days; however, emergence was most uniform (i.e. with least variation about the mean) after 63 days of chilling.

Germination (seed leaf emergence) will occur after 32 days at 20°C and 42 days of chilling, although the mean average date of emergence did decline to 28 days with increasing periods of chilling to 84 days. The exposure to warmth causes the embryo to mature until it fills the seed, continued growth ruptures the seedcoat and eventually the seedling emerges.

The accurate determination and application of information of this type permits the development of a simple schedule for the programming and timing of germination. Assuming that the viability of the sample is adequate, it becomes possible to chill and then warm stratify under artificial conditions so that the seeds can be station sown after 90 days (63 days of chilling + 27 days of warm stratification) with the expectation of emergence in 3 to 5 days.

The response of all the Asiatic species, which were the subject of these observations, was remarkably similar to, and corresponded closely with, the results previously reported for the North American species; however the germination response to chilling for periods of less than 42 days was not nearly so marked in the Asiatic species. It would appear that the general schedule described above would prove successful for the following species:

Asiatic	*American*
M. campbellii subsp. *mollicomata*	*M. virginiana*
M. dawsoniana	*M. macrophylla*
M. sprengeri	*M. tripetala*
M. cyclindrica	
M. kobus	
M. × veitchii	

It should be emphasised that these observations were made on freshly harvested and extracted seeds and that responses from seeds obtained from commercial sources were usually erratic and unreliable even if viability appeared to be acceptable.

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HORTICULTURAL ROCKWOOL AND DIATOMACEOUS EARTH IN PLANT PRODUCTION SYSTEMS

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Containerised plants were traditionally propagated and grown in soil-based media but there has been a major shift towards soilless media in the last 30 years. Peat, sawdust, pinebark, sand, vermiculite, and perlite are all used in a variety of mixes but the search for suitable ingredients continues. This paper deals with developments in the use of horticultural rockwool and diatomaceous earth as components of plant production systems.

HORTICULTURAL ROCKWOOL

This material was developed in Denmark in the late 1960's and has been used increasingly in Europe since the mid-1970's where the major usage is for growing greenhouse vegetables and flowers. Some use is made of rockwool for plant propagation in Europe but usually for plants which are subsequently grown on in a complete rockwool system.

Horticultural rockwool was not released onto the Australian market until 1982 and the material has mainly been used in plant propagation—particularly of Australian native plants—although some rockwool systems for cut flowers have been developed.

Biggs (1) described the manufacture and properties of horticul-