# Plant Propagation Techniques: A Historical Perspective©

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## INTRODUCTION

It is always interesting to take a few steps back and view a subject from a historical perspective. Invariably, you come away impressed with the knowledge available in the literature including ancient references. You may also find that techniques that are considered new today were available at much earlier times. In this brief review, I will try to provide a perspective on modern plant propagation techniques as it relates to earlier times.

## SEEDS

The primary mode of propagation now as in ancient times is by seeds. Domestication of crop plants required the ability to selectively propagate superior plants from seeds. Therefore, it is understandable that the earliest agriculturists keenly observed seed production, dissemination, and germination. Some of the earliest references to plant propagation come from Theophrastus, a Greek philosopher (300 BC) and disciple of Aristotle. He described many aspects of plant biology in his two books "Historia de Plantis" and "De Causis Plantarum" (Theophrastus, 1961). He must be considered the first seed biologist. He understood that the mother plant transferred nourishment to the seed that was important for its subsequent germination. He stated "all plant seed has in itself a certain amount of nourishment which is produced with it at the beginning just as is the case in eggs."

Seed dispersal was also evident to Theophrastus. He describes wind dissemination in pines. "While the cones are still fast to the trees, the seeds leap forth and leave them empty." Theophrastus appears to be well acquainted with seed dormancy. He describes several circumstances related to dormancy. This comes from his determination that seed germination is impacted by circumstances, stating, "in the seeds themselves, in the habitat, in the state of the atmosphere and in the season at which each is sown". Therefore, he suggests that some seeds require light for germination —"Germination begins earlier in sunny places". Remarkably, he also describes the need for some seeds to after-ripen to relieve seed dormancy —"Another thing which makes a difference as to the rapidity with which the seeds germinate is their age: for some herbs come up quicker from fresh seeds … some come up quicker from old seeds". He describes germination in grape hyacinth (*Muscari*) as being spread over time—"it is said to be a peculiarity of *Muscari* that all the seeds do not germinate at once, but some in the next or in the third year". Hard seeds with impermeable seed coats were also known to Theophrastus, where he notes that certain legume seeds need to be treated with "nitre" (possibly a caustic base) to germinate. He also was aware that the climate during seed ripening affected the degree of hard seeds found at harvest (Evanari, 1981).

Modern advances in seed technology have centered on various seed treatments that improve seedling emergence including seed priming, coating, and pregermination (Hartmann et al., 2002). However, from a historical perspective, these are new

practices based on old themes. Seed priming is a controlled seed hydration treatment applied to seeds prior to sowing that promotes earlier and more uniform seedling emergence. It has a long tradition as a seed treatment. Theophrastus observed that cucumber seeds soaked in water prior to sowing would induce faster emergence (Evanari, 1981). In 1600, Oliver de Serres described the "clever trick" of soaking grains (wheat, rye, or barley) for 2 days in manure water followed by drying in the shade before planting the seeds. He noted that soaked seeds emerged more quickly avoiding "the danger of being eaten away by soil pests" (cited in Taylor, 1998). In experiments conducted in 1855, Charles Darwin hinted at the possibilities for osmotic seed priming (Allan, 1977). Darwin submerged seeds in salt water to show that they could move across the sea between landmasses as a means to explain geographic distribution of plant species. Not only did seeds survive immersion in cold salt water for several weeks, but some species like cress and lettuce showed accelerated germination.

Seed pelleting is the practice of surrounding the seed with an inert material to facilitate sowing. This too was practiced in ancient times as Pliny describes treating vegetable seeds in "enclosed pellets of goats' dung, each seed in a separate pellet, they came up wonderfully".

Pregerminated seeds were introduced commercially in 1995 for bedding plant species (impatiens). Pregerminated seeds are germinated in the lab under controlled conditions and slowly dried after the radicle begins to emerge. This insures fast germination at near 100%. However, Liberty H. Bailey described this technology as early as 1896. A quote from Bailey's *The Nursery Book* (1896) demonstrates that "new" is truly a relative term as he describes regermination. "It is a common statement that seeds can never revive if allowed to become thoroughly dry after they have begun to sprout. This is an error. Wheat, oats, buckwheat, maize, pea, onion, radish, and other seeds have been experimented upon in this direction, and they are found to regerminate readily, even if allowed to become thoroughly dry and brittle after sprouting is well progressed. They will even regerminate several times."

## CUTTINGS

In modern time, we think of cuttings as the primary method for clonal propagation. Although cuttings were used for propagation since ancient times, they are not as important as grafting and layering for propagation. This is mainly due to the environmental control needed to root leafy cuttings. Mist propagation is a relatively modern technology only becoming common in commercial nurseries after 1960. However, there are references to cutting propagation in older texts.

A discussion of the historical aspects of cutting propagation must again begin with Theophrastus. He describes propagation in herbaceous and woody plants by both stem and root cuttings. In his description of taking stem cuttings in olive, he makes a reference to the concept of juvenility as it relates to rooting. He recommends taking cuttings from the base of the tree rather than the tops. Cuttings from the base of the tree are more juvenile than those taken from the top. In a similar sense, the Roman, Columella, ca. 1 A.D., in great detail describes taking mallet stem cuttings in grape (Columella, 1948). A mallet cutting is a combination of current and previous season's stem growth. He states that cuttings root better when taken from nonfruiting wood.

Although the concept of auxin and its ability to stimulate rooting in cuttings is a modern concept, Theophrastus recognized that some plant species rooted from

cuttings more easily than others. He and his contemporaries must have experimented with treatments to improve rooting. In one case, Theophrastus describes improved rooting in fig cuttings by setting them in squill bulbs. Could this be a coarse auxin treatment?

An interesting observation was made by Dr. M. Kawase in the 1970s (Kawase, 1971). He found that an extract from willow stems could increase rooting in stem cuttings from a variety of species. However, the benefits of willow on rooting in cuttings was apparently known as early as 1716, when Agricola (1716) described drilling holes in a willow branch into which stem cuttings of other species were inserted prior to planting them for propagation.

Thomas Barnes in 1758 published his research on cutting propagation (Hill, 1758). I found his work to be in the best tradition of the International Plant Propagator's spirit of to seek and share. The following is quoted from book. "The occasion and purpose of this work. The difficulty of propagating some shrubs in the common way, and the small increase that can be made from others by the usual methods, brought into my thoughts to try whether some expeditious manner could not be invented of raising a large number.

Every nurseryman will be glad to know this: for if he can, when he has got a new shrub, raise twenty or thirty instead of three or four, it will be a great increase for his profit. This made me resolve not to be disheartened at one or two trials. I have made them many various ways upon four and twenty sorts of trees and shrubs. Not trusting to one or two samples of each, but using several dozens of every kind, and trying them in all the different conditions of culture. I kept a journal of them all, which I have here faithfully transmitted to the publick; every one will see how far each method succeeded, and which deserves the preference."

His experiments centered on using a plaster to coat the basal end of root and stem cuttings. His research claims success using this method, because it stopped the portion of the cutting inserted into the rooting medium from rotting. He adequately describes his methods, along with rooting successes and failures, but interestingly there are no untreated controls used to contrast his methods. His plaster is described as follows.

"Melt together, in a large earthen pipkin, two pound and an half of common pitch, and half a pound of turpentine. When melted put in three quarters of an ounce of powder of aloes; stir them all together; and set the matter on fire; when it has flamed a moment, cover it up close, and it will go out. This must be done three times : it must be done in the open air, for it would fire a house. Melt it again, and put in three ounces of yellow wax shred very thin, and six drams of mastich in powder. Strain it through a coarse cloth into a pan, and set it by to cool."

## LAYERING

Layering has been practiced since ancient times. It is a simple technique that induces a stem to form roots while it is still attached to the mother plant. Before auxin treatments, greenhouses, and misting, layering was the more common way of propagating trees on their own roots. Philip Miller in his influential *Gardeners Dictionary* (1754) describes layering of trees in a way that could be used in a modern text on propagation. For easy to root plants, "Take some of the boughs, and lay them into the ground about half a foot deep in fine fresh mould, leaving them with the end of the layer about a foot, or a foot and an half, out of the ground, and keep them moist

during the summer season, and they will probably have taken, and be fit to remove, in autumn." For plants that are more difficult to root, he suggests a wounding treatment. "Tie a piece of wire hard round the bark of the bough, at the place you intend to lay in the ground; prick the place above the wire thro' the bark with an awl in several places, and then lay it in the ground, as before directed".

Pot or air layering is not a common propagation technique for modern propagators, but at one time it was common place for those plants where the stems could not easily be bent over to the ground. Several interesting devices were designed to air layers that are unfamiliar to most modern propagators. These included various types of cones, pots, and multiple tubes. Still, the technique is simple as described by Miller. "If … the boughs of which cannot be bent down to the ground, then you must make use of osier-baskets, boxes, or pots, fill'd with fine-sifted mould, mix'd with a little rotten willow-duft, which will keep moisture and assist the layer in taking root."

## GRAFTING AND BUDDING

Descriptions of grafting and budding are found in all the early important works that deal with agriculture (Theophrastus, Pliny the Elder, Columella). They include discussions concerning compatibility, the best season for grafting, and specific techniques. Theophrastus describes wedge-grafting "… after splitting the stock and giving the scion a wedge-like shape then drive it in with a mallet to make the fit as tight as possible." Then to avoid having the graft dry out. "… first bandage the site with layers of lime bark and then plaster mud over it mixed with hair: to make the fluid remain and keep sun, rain, and cold from doing any harm."

Columella (ca. 1 AD) describes different types of grafting in use at that time. "The ancients have handed down to us three kinds of grafting: one in which the tree, which has been cut and cleft, receives the scions… the second, in which the tree having been cut admits to such a size as will fill the space given by a wedge… A third kind of grafting is our own invention, being a very delicate operation, it is not suited to every kind of tree… Seek out young and healthy branches, and you should look out on them for a bud which has a good appearance and gives sure promise of producing a sprout. Make a mark round it enclosing two square inches, so that the bud is in the middle, and make an incision all round it with a sharp knife and remove the bud carefully… also choose the healthiest branch of the other tree, which you are going to inoculate, and cut out a part of the bark of the same dimensions… Then fit the scutcheon which you prepared to the part which you have bared."

**Budding.** Miller (1754) indicates that budding (or inoculating as it was called) is preferred to grafting for most fruit trees. His description of T-budding stands the test of time. "With your knife make an horizontal cut cross the rind of the stock, and from the middle of that cut make a slit downward about two inches in length, so that it may be in the form of a T... then having cut off the leaf from the bud, leaving the footstalk remaining, you should make a cross cut about half an inch below the eye, and with you knife slit off the bud … in the form of an escutcheon… then having gently raised the bark of the stock with the flat haft of your penknife … you should thrust the bud therein…. You must tie them closely round with bass-mat, beginning at the underpart of the slit, and so proceed to the top, taking care that you do not bind round the eye of the bud, which should be left open."

Miller also has a remarkable discussion about leaving part of the wood on the underside of the bud. "I beg leave to observe, that tho' it is a practice to divest the

bud of that part of the wood which was taken from the shoot with it; yet, in many sorts of tender trees, it is best to preserve a little wood to the bud, without which they often miscarry."

**Approach Grafting**. Apparently, approach grafting grapes was an early method of propagation as described by Columella (ca. 1 AD). He called the procedure terebration or boring. It involved boring a hole in the understock that was brought close enough to a fruitful stem to allow the wounded stem to be passed through the hole made in the understock. "being lightly pared all around in such a way that the bark alone is removed, it is fitted to the hole." In this way, "it is nourished at its mother's breast until it grows into the other vine."

Philip Miller (1754) on approach grafting. "This method of grafting is used, when the stock you intend to graft on, and the tree from which you would take the graft, stand so near (or can be brought so near), that they may be joined together. The method of performing it is as follows: pare away the rind and the wood on one side about three inches in length… then cut a little tongue upward in the graft, and make a notch in the stock to admit it… the tongue will prevent their flipping, and the graft will more closely unite with the stock… You must tie them with some …soft tying; then cover the place with grafting clay, to prevent the air from entering to dry the wound. This operation is always performed in April or May… and is commonly practiced upon oranges, myrtles, jasmines, walnuts, firs, pines, and several other trees, which will not succeed by common grafting or budding."

**Root Grafting**. Most types of grafts are described in detail since antiquity. However, one grafting type was originated in the USA (Hedrick, 1988). Joseph Curtis (1786 - 1882) from Manchester, Ohio, was grafting fruit trees at the age of 16. At that time, understocks for fruit trees were in limited supply. He decided to use root pieces for understocks in apple grafting and thus developed the method of root grafting.

**Understocks.** The impact understocks have on the grafted tree have been recognized since the time of Theophrastus (300 BC). He states that "like always coalesces readily with like" in reference to grafting compatibility. He also describes using wild olive as an understock for cultivated olives. "It is reasonable that trees so grafted should bear finer fruit, especially when the scion is from a cultivated tree and the stock from a wild tree of the same bark … this is why it is recommended to plant wild olives first and later graft them with cultivated buds or twigs. For the grafts hold better to the stronger tree, and since this tree attracts more food they make it a finer producer."

Philip Miller (1754) has an extensive discussion of understocks under the section on nurseries in his Gardeners Dictionary. For example, he discusses the merits and disadvantages of using almond understocks for peaches. "There are some persons who recommend the almond-stock for several sorts of tender peaches, upon which they will take much better than upon plum-stocks: but these being tender in their roots, and apt to shoot early in the spring, and being of short duration are by many people rejected: but such tender sorts of peaches which will not take upon plum-stocks, should be budded upon apricots, upon which they will take very well, and all sorts of peaches which are planted upon dry soils, will continue much longer, and not be so subject to blight if they are upon apricots."

Miller also describes the practice of double working to take advantage of the benefits of an apricot root system and graft compatibility of peach on plum.

"Therefore it is the common practice of the nursery-gardeners, to bud the plum-stocks either with apricots, or some free-growing peach; and after these have grown a year, they bud the tender sorts of peaches upon these shoots... and these the gardeners term double-work'd peaches."

Dwarfing understocks were developed at the East Malling experiment station in England during the early 1900s. However, Philip Miller (1754) described using dwarfing stocks as a common practice over one hundred years previous where he mentions Dutch dwarf-stock or Dutch Paradise-apple. "Apples are grafted or budded upon stocks raised from seeds which come from the cyder-press, or upon crab-stocks, the latter of which are esteemed for their durableness... These should be raised from seeds, ... for those procured from suckers, are not near so good; but for small gardens, the paradise-stock hath been for some years past greatly esteem'd; it being of very humble growth, causeth the fruit-trees grafted or budded theron to bear very soon, and they may be kept in small compass: but these are only proper for very small gardens, ... and seldom arise to any size to produce fruit in quantities, unless the graft or bud is buried in planting, so that they put forth roots." According to Bailey (1897) Paradise and Doucin understocks were still being used as dwarfing understocks in the early 1900s.

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