

Stem cuttings under mist in the summer also give good results. The information on this method I find is scanty. A couple of references mentioned pieces of roots three inches long to be planted deeply in the soil. This to be done right after foliage turns yellow in the summer. Perhaps that is how it is done in Holland, since imported plants have a long "neck" with most of the eyes along that part, indicating that they were planted quite deeply. One nurseryman I talked to said he understood that such a method required two years. Perhaps that is why it is only mentioned in references I have seen.

Listed below are other perennials which, in one text or another, give root cuttings as a method of propagation, but without further details. Since we either do not grow the plant at all, or if we do it is by another method, I cannot give further details:

Arabis
 Asclepias
 Dictamnus
 Gypsophila paniculata
 Lobelia
 Plumbago (Ceratostigma)
 Saponaria
 Saxifraga
 Trollius
 Yucca

I rather imagine that in some of the above instances there may be confusion of a technical nature, as for instance on first thought we think of Plumbago larpentae as being propagated by root cuttings. Since however, one selects the growing tip end of the "root", more technically we are dealing with an "underground stem". Off-shoots of Yucca, I think, would be classified as rhizomes, which technically are underground stems.

References: Plant Propagation - Mahlstedt & Haber
 Propagation of Plants - Kains & McQuesten
 Commercial Flower Forcing - Laurie & Chadwick
 The Book of Perennials - A. C. Hottes
 Contemporary Perennials - Cumming & Lee
 Popular Perennials - T. W. Sanders

PROPAGATING WOODY PLANTS BY ROOT CUTTINGS

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The root cutting method of propagation is one of the least frequently used of all the methods of vegetative propagation. The primary reason for the relative rarity of this method is that the plants for which it is the best technique are infrequently grown in the average nursery. A secondary reason is that it is relatively inconvenient to

secure the cuttings. Either the whole plants to be propagated must be dug up to secure suitable roots for propagation, or else the soil around stock plants must be excavated to expose the roots prior to their removal, at best a rather tedious procedure.

Despite the difficulties involved in securing propagating material, root cutting propagation is by far the best method for increasing certain special plants which will not root from stem cuttings. It is also useful for increasing certain clonal varieties of plants which do not come true from seed, do not bear reliable seed, or are staminate clones of dioecious genera. Here are a few examples of plants which are efficiently propagated by root cuttings. The staminate or male plants of Ailanthus glandulosa bear unpleasantly scented flowers, but the scentless pistillate clones, including the colorful red fruited form can be easily propagated by root cuttings. The wilt resistant clones of Albizzia julibrissin, "Tryon" and "Charlotte", do not give reliably resistant seedlings and those of the hardy form "Rosea" are not all of equal hardiness. All three can be grown from root cuttings but not from stem cuttings. Stem cuttings of the D. E. D. and Phloem Necrosis resistant Christine Buiseman Elm (Ulmus carpinefolia) are very difficult to root but root cuttings are entirely satisfactory, and cutting propagation is necessary to preserve the resistance of the clone. Unlike most other poplars, Populus tremula and our American P. tremuloides are almost impossible to propagate from stem cuttings, but their roots regenerate new plants very easily.

The seeds of the pithy, stoloniferous species of *Rhus* such as *copallina*, *glabra* and *typhina*, germinate slowly and irregularly and the attractive cutleaf forms of the latter two species will not reproduce by seed, but all will grow from root cuttings. The many ornamental varieties of Bamboo do not set reliable seed in this country and are entirely reproduced by the spreading underground stolons (in this case underground stems and not true roots).

Propagation from roots is also a most valuable but neglected tool for restoring a state of juvenility in certain plants where this is a most valuable condition for subsequent propagation. For example many strains of valuable clonal Apple understocks are reproduced by mound layering. This method is most successful (and sometimes only successful) if the mother plants are in a physiologically juvenile condition (thorny, twiggy, and non-flowering). If the mother plants are allowed to grow up for a few years and change to the mature (flowering, smooth, less twiggy) condition, layering or cutting propagation becomes most difficult. Such clonal understocks which have for one reason or another been allowed to grow out of the juvenile condition, can be easily and rapidly restored to it by growing new plants from root cuttings, even if secured from thoroughly mature specimens. We have experimentally produced truly juvenile plants from 40 year old specimens of *Malus baccata* at Princeton, by this method. The advantages of this technique in work with clonal root stock selection and evaluation are obvious.

Techniques

The methods used in root cutting propagation are relatively simple. As mentioned above, the main problem lies in securing the propagating material. The timing of the propagation is very important. Roots taken in the fall will callus over and eventually form adventitious buds and sprout new aerial stems, but the process is much slower than in the early spring and losses from rotting over the winter are excessive. We have never been successful in fall outdoor root propagation at Princeton and the cuttings taken at that time invariably either heave out of the ground or not before spring if they remain in the ground. Roots of Robinia and Rhus taken from fall dug plants have not been successfully overwintered in cold storage either, whether stored in plastic bags, damp peat, or dry sand. Consequently, the roots needed for propagation are dug as soon as the frost goes out of the ground in the spring, usually in late February or early March. In the case of varieties which are propagated out of doors, the roots are cut up into 2 and 3 inch lengths and packed in layers in boxes of almost dry sand. They are stored in a cool place for three weeks to permit partial callusing of the cuts. Roots of 1/2 to 1 inch diameter are selected for the propagation of Rhus, Campsis, Ailanthus, Robinia, Sassafras, and Populus. Roots of smaller rooted species such as Rosa nitida, lucida, blanda et al, Comptonia, Clerodendron, and Zanthorrhiza, should be of a minimum 1/4 inch diameter. When the ground has dried out sufficiently for plowing, a sandy piece of soil is plowed, disked thoroughly and boarded smooth. Then it is marked out in rows about 2 inches deep. The roots are sown by hand in the rows and soil is raked over the roots. The rows are marked with small stakes driven in every 25 feet and at the ends of the rows as guides for cultivation until all the cuttings have sprouted and the tops are visible above the ground. The rows are also burned over several times prior to sprouting with a liquid propane flame thrower which destroys the crops of weeds which germinate prior to the emergence of the cutting shoots. After sprouting of the cuttings, normal nursery culture is followed and the cuttings are hilled up moderately in cultivation for weed control and to prevent lodging of the plants during summer wind storms.

In the case of valuable trees such as the Albizzia varieties, Christine Buiseman Elm, and Staminate Morus clones a difficult procedure is followed. Here the roots are cut into 3 inch lengths and potted in a mixture of sand and peat into 2-1/2" deep peat pots. All roots, like stem cuttings, exhibit "polarity". That is to say, the new sprouts emerge at the "top" of the root section or the portion nearest the trunk or stem of the parent plant. Consequently, the cuttings should be potted up vertically with the "top" of the cutting at the surface of the potting mix and with the lower part from which the roots will emerge, at the bottom. To avoid confusion in potting, the cuttings when cut up with shears or knife should be cut square across the "top" and on a slant at the "bottom". After potting in the moist but not wet mix, the pots are set up in a cool sash house or frame and not watered for two weeks to permit callusing and prevent rot. Of course the pots must not become bone dry, so a light sprinkling may be necessary if the weather is bright and dry. In four weeks

the cuttings will have begun to sprout and after danger of frost is past, they can be planted out in the nursery pot and all, and irrigated when necessary until well established. Once they are established, the several sprouts arising from the top of most cuttings should be trimmed off, leaving the strongest and straightest one to form the trunk of the young tree.

There are several interesting points in the propagation of Bamboos (of which the genus *Phyllostachys* contains the hardiest species of the reasonably tall varieties). They are included in this discussion because they propagated from spreading underground stolons even though these are not true roots. The stolons are dug up in early spring, choosing young stolons without aerial culms or stems or with only short ones. The stems are cut off, if present, and the stolons are cut up into 3 or 4 jointed sections and planted in 3 inch deep furrows or directly into containers, and covered with soil. New stems or culms sprout from the joints in about 4 weeks' time. If the stolon sections are planted horizontally, a typical spreading clump develops. If they are planted vertically with the tip-most or apical portion up, a compact, non-spreading clump develops which is much more useful in landscape work as it does not spread out excessively. Bamboos, being grasses, respond to heavy nitrogen fertilization.

It is not frequently realized that certain desirable shrubs such as named clones of Japanese Quince (*Chaenomeles*), French Hybrid Lilacs, and Wisterias are easily propagated by root cuttings removed when the plants are dug for sale in the early spring. Of course in these clonal varieties, own rooted plants must be first started from soft wood cuttings to get a start of the true variety, as grafted plants are useless for this purpose. Similarly, pistillate or fruiting strains of *Celastrus scandens*, (which roots very poorly from stem cuttings) can be propagated from cuttings taken from sizable roots. Such cuttings are best handled like tree root cuttings and potted up in peat pots for later lining out.

Root cuttings, although admittedly of limited usefulness in the whole field of propagation, are of great value in the production of a few special plants. The technique should not be forgotten, for it is often an inexpensive substitute for more costly grafting or very low yielding attempts at soft wood cutting propagation. The chart which follows summarizes some of the more important plants which can be propagated by root cuttings and the methods used.

PLANTS OFTEN GROWN FROM ROOT CUTTINGS

<u>Genus</u>	<u>Species</u>	<u>Variety</u>	<u>Dimension of Cutting</u>	<u>Where Propagated</u>
Iilanthus	glandulosa	pistillate	1" X 3"	Pot Vertically
Aesculus	parviflora	-	$\frac{1}{2}$ " X 3"	" "
Albizzia	Julibrissin	"Charlotte"	$\frac{1}{2}$ " X 3"	" "
		"Rosea"		" "
		"Tryon"		" "
Amelanchier	stolonifera	-	$\frac{1}{4}$ " X 2"	Outside
Aralia	spinosa	-	$\frac{1}{2}$ " X 2-3"	" "
Bamboo	(see Phyllostacys)	-	-	-
Campsis	radicans	-	$\frac{1}{2}$ " X 3"	Outside
Celastrus	scandens	pistillate	$\frac{1}{4}$ " X 2-3"	Pot Vertically
Chaenomeles	lagenaria	Names Clones	$\frac{1}{4}$ " X 3"	" "
Clerodendron	trichotomum	-	$\frac{1}{2}$ " X 2"	" "
Comptonia	peregrina	-	$\frac{1}{4}$ " X 3"	Outside
Hydrangea	quercifolia	-	$\frac{1}{4}$ " X 2"	Pot Vertically
Malus	species	Dwarfing Under-stocks		Outside - vertically
Morus	species	Staminate clones	$\frac{1}{2}$ " X 3-4"	Pot Vertically
Myrica	pennsylvanica	Pistillate	$\frac{1}{4}$ " X 3"	Outside
Phyllostachys	species	Hardy Bamboos	3 or 4 joint stolons	Outside
Populus	alba	"Bolleana"		
	tremula	"Richardsoni"	$\frac{1}{2}$ " X 3"	Pot Vertically
	tremuloides	fastigata	$\frac{1}{2}$ " X 3"	" "
		-	$\frac{1}{2}$ " X 3"	" "
Prunus	glandulosa	Dbl. Pink or white	$\frac{1}{4}$ " X 2-3"	" "
Rhus	copallina	-	$\frac{1}{2}$ "-1" X 3"	Outside

<u>Genus</u>	<u>Species</u>	<u>Variety</u>	<u>Dimension of cutting</u>	<u>Where Propagated</u>
Rhus (continued)	glabra	laciniata	$\frac{1}{2}$ "-1" X 3"	Outside
	typhina	laciniata	$\frac{1}{2}$ "-1" X 3"	"
Robinia	hispidia	-	$\frac{1}{2}$ " X 3"	"
	pseudoacacia	"Shipmast" vars.	$\frac{1}{2}$ "-1" X 3"	"
Rosa	blanda	-	$\frac{1}{4}$ " X 2-3"	"
	nitida	-	$\frac{1}{4}$ " X 2-3"	"
	virginiana (et al)	Alba	$\frac{1}{4}$ " X 2-3"	"
Rubus	species	-	$\frac{1}{4}$ " X 2-3"	"
Sassafras	albindum	-	$\frac{1}{2}$ " X 3"	Pot Vertically
Syringa	Vulgaris	French Hybds.	$\frac{1}{4}$ " X 2-3"	"
Ulmus	carpinifolia	"Christine Buisseman"	$\frac{1}{4}$ "- $\frac{1}{2}$ " X 3"	"
Wisteria	species	Names vars.	$\frac{1}{2}$ " X 3"	"
Zanthorrhiza	simplicissima	-	$\frac{1}{4}$ " X 2"	Outside

MODERATOR GALLE: We have a little time. There are a few other plants that might be mentioned, of which buckeyes are one, which are easily rooted from root cuttings, also some of the rhododendron. It might also be mentioned that variegated plants will not propagate true to form by root cuttings. You have to go to stem cuttings.

Are there any questions on this subject you would like to ask the members of the panel here?

MR. LOWENFELS (White Plains, N. Y.): Mr. Flemer, have you tried lilacs from root cuttings?

MR. FLEMER: Yes, we have, Mr. Lowenfels. I think it is a method we are going to use more in the future. This is a case such as Ken Fisher mentioned earlier. What you propagate from are not true roots, they are really spreading underground stems. If you have been propagating lilacs from stem cuttings, it may take several years before they begin to spread out and form stolons. But once you start propagating from that type of underground stolon, then the plants produce stolons very readily. Also, some varieties produce stolons are easily propagated by this method and some of the others, particularly some of the dwarf dark red types, produce very few stolons and are not by any means successful.

MODERATOR GALLE: Any other questions?

MR. H. R. HUROV (Cornell): There is just a point I want to point out about rooting pine cuttings. The Japanese apparently have done quite a bit of work on this the past ten years and they have tried a number of different species. They found in the older pines there is an inhibitor and they have managed to remove or inactivate the inhibitor by dipping the cuttings in silver nitrate. I don't know the concentration. They then treat it with auxin and have gotten fairly good results.

MR. JIM WELLS: Fred, I would like to ask Mr. Grigsby if he has done any treating of the unrooted cuttings with hot water? I understand that is being done in Holland. The method is to remove the resin from the base of the cutting.

MR. GRIGSBY: No, I have not. Last year in the notes of Mr. Payne he mentioned hydrogen peroxide. We used that among others. I plan to try that this year.

DR. O'ROURKE: Mr. Moderator, I would like to add a comment. In checking the literature I found that a great many workers had removed the resin from the bottom of the cutting and in every case, rooting and survival was better than when they left it on.

MR. ROLAND De WILDE, JR.: I was going to ask Bill Flemer if I heard rightly that he said he had trouble rooting Celastrus scandens.

MR. FLEMER: We have never been successful in rooting them from stem cuttings, either hard wood or soft. Most of these Celastrus scandens which are sold in the trade, I am sorry to say, particularly

from our brother nurseries in the South, is orbiculata, and that is an easy plant to propagate. The true scandens with the long fruit clusters out on the end of a little terminal shoot, is very, very difficult to propagate from stem cuttings. Root cuttings are quite successful.

It is easily grown from seed but you have to wait for a long time, you see, until they get old enough to flower and you can determine which are male or female. If you get the established female plants, you can reproduce it by root cuttings.

DR. THOMAS F. CANNON (North Carolina State College): I would like to ask Mr. Grigsby if he had any difficulty in getting the rooted cuttings to grow. The reason I am asking, we have rooted a few cuttings of fir but we have not been able to get them to produce new root growth after they have rooted.

MR. GRIGSBY: No. most of our cuttings that we have rooted, and cuttings that we have potted, have grown quite well.

MR. HANS HESS: I would like to ask one question about these pines from cuttings. What sort of a root system develops on the plants when they are set out? Does it continue as a one-sided root system? If they are like the firs or spruces rooted from cuttings they continue lateral root growth without making a balanced root structure which can be dug.

MR. GRIGSBY: I have in mind to check just what sort of a system the root does develop into. I hope that they will develop a system similar to the parent plant. I don't know.

MR. JIM WELLS: I would like to ask if any work is being done by Mr. Grigsby on checking the rooting of different plants, because it obviously does vary from plant to plant.

MR. GRIGSBY: Yes, I have. However, most of my cuttings have been taken from at least ten trees in any one study.

MR. WELLS: You haven't segregated the cuttings?

MODERATOR GALLE: I think earlier work showed there was some variation within parent plants.

MR. WELLS: I was astonished a few years ago when a man came to see me and we talked about the rooting of hemlock. He said he had a plant in his garden which he had trimmed in the autumn, thrown the cuttings on the rubbish pile and in the spring they were all rooted. I know the man and I went to see the plant and I took about 20 cuttings of it and stuck them in the bench and all 20 rooted without any trouble whatsoever.

I never did any more about it because I wasn't interested in hemlock. There is a plant which will root.

MR. CASE HOOGENDOORN (Newport, R. I.): What variety?

MR. WELLS: Just a seedling, a plant in somebody's yard.

MODERATOR GALLE: Too bad that wasn't weeping hemlock.

MR. HUROV (Cornell): Mr. Grigsby, what do you attribute your success with on pine - temperature, or a number of factors?

MR. GRIGSBY: I think it is a combination of the factors. We can possibly get rooting by varying some of those but there has to be a balance. I think the temperature, high temperature, higher than most people are using, is partially responsible and the mist system. I was using 45 seconds per minute mist, which is more than most people are using.

MR. HUROV: You didn't have shade?

MR. GRIGSBY: No shade. I think that had a lot to do with it.

MR. FLEMER: On the pine business, about 25 years ago at the Yale School of Forestry they did a great deal of work in rooting white pine from cuttings. What they were trying to do was select plants which were highly resistant to blister rust, which was then a big problem in Connecticut and they developed seed orchards which would give them rust-resistant seedlings. They found an enormous clonal variation in rooting ability. Cuttings from certain trees which were selected would root as high as 75 or 80 percent and with certain other trees which didn't seem to differ in any way, would only root 3 or 4 percent. But with all of the trees tried, the cuttings taken from the lower third of the tree rooted much better than those from any higher portion. In other words, the rooting got progressively worse as you went from the bottom of the tree up to the terminal leader.

MODERATOR GALLE: I believe we have used up nearly all our time. We want to thank all the members of the panel this morning.

THURSDAY AFTERNOON SESSION

December 7, 1961

The second session convened at 1:30 o'clock, President Van Hof presiding.

PRESIDENT VAN HOF: We are ready to go ahead with our program again and I am happy to present to you Dr. Charles Hess, Purdue University. I think he talked on this subject last year, and this is a continuation.