THE VEGETATIVE PROPAGATION OF SOME FOREST TREES

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Woody plants have been vegetatively propagated for more than 2000 years, but not until the past twenty-five years has much attention been given to the vegetative propagation of forest trees, interest in the subject having probably increased with increasing awareness of the possible importance of the clone in forestry (16). Rehder (15) recognized five forms or variants of eastern white pine (Pinus strobes L.) but these forms were based upon differ ences of little interest to foresters.

The writer worked for some years on the vegetative propagation of woody plants in general before he concerned himself especially with the application of these investigations in the improvement of forest trees by the perpetuation of the best. It was at the suggestion of Professors R. P. Holdsworth and A. D. Rhodes of the Department of Forestry of the University of Massachusetts that this work was undertaken, first with white pine and then with other species.

The work of the writer with cuttings of forest trees was done in a greenhouse, sand or mixtures of sand and peat being the rooting medium. Stem cuttings, usually of the most recent year's growth; were obtained from trees about thirty years old. Cuttings of several. species of trees are known to root better (in larger percentages) if taken from younger rather than from older trees. It would seem preferable, therefore, to take cuttings as early in the life of a tree, whether a pine or some other genus, as soon as its desirable qualities become evident. This is probably most true of species:the cuttings of which are rooted only with some difficulty.

*Exact geographic origin is known.

Generally speaking, cuttings of white pine root with more difficulty than cuttings of some other conifers, e.g. Norway spruce (Picea Abies (L.) Karst,) and eastern hemlock (Tsuga canadensis (L,) Carr,),

As with trees in other genera, cuttings from some white pines develop roots more readily than those from other white pines of the same age because the clones differ in ability to root. This past fall and winter, cuttings were obtained from sixteen individual white pine trees which Professor Holdsworth considered to be superior. Cuttings from these trees were taken in November, December, January, and early March. Taken in each of these four months, cuttings from one tree have rooted in larger percentages than cuttings from any of the other trees. Here we may have a clone that is not only superior from the viewpoint of forestry but one which can be propagated vegetatively without too much difficulty. The ability to root may turn out to be almost as important a factor as quality of tree or any other desirable characteristic.

White pine cuttings taken from December to March have rooted in larger percentages than have those taken in October and November, and it now appears that lateral shoots of branches may be less difficult to root than terminal shoots, especially long terminal shoots of such branches. Treatment of cuttings of white pine with a growth substance, a root-inducing substance such as indolebutyric acid, is helpful, often necessary, for rooting,*

The propagation of a few other pines by cuttings will now be considered briefly, for what is learned about one species may be helpful in handling related ones.

Rooting of cuttings of western yellow pine (Pinus ponderosa Dougl.) by Mirov (12) was improved by treatments applied to cuttings some weeks after their insertion in the rooting medium. It is of interest that in this case, delayed treatments were beneficial, but it is preferable, less work, to treat cuttings before they are inserted in the rooting medium if such treatment gives similar results.

Cuttings of a hybrid pine were found by Duffield and Liddicoet (6) to show great clonal differences in ability to root, and this was true in successive years. Again, it would appear that trees must be selected that can be propagated vegetatively if they are to be so propagated.

There has been, and with good reason, some concern as to whether or not pines and other conifers grown from cuttings will develop into erect and normal trees. Douglas-fir (Pseudotsuga taxifolia (Poir.) Britt.) grown from rooted cuttings by McCulloch (9) had no well-developed leader in the third season. Mirov (11) observed that Monterey pine (Pinus radiata Don) grown from rooted cuttings developed well and normally but he was still uncertain about eastern white pine and western yellow pine five years after cuttings were rooted. However, and here is evidence that such adjustment may take a little time, Deuber (2) noted that the new shoot on some rooted cuttings of Norway spruce did not develop normally at first, but new growth approached normalcy in the second year and was vertical and normal in the third year, indicating that the plagiotropic habit of growth may be only temporary.

When mention is made of treatments or of treated cuttings in this paper, the reference is to the use of root-inducing substances.

White pines grown from cuttings that were rooted by the writer are now about nine feet in height, upright and perfectly straight in most cases, and they have increased in height at the rate of fourteen to eighteen inches a year in each of the past five years. These pines were grown from cuttings made indiscriminately from lateral and terminal shoots. More recently, when making cuttings of white pine, we have been distinguishing between lateral and terminal shoots of branches to see whether that difference has any effect on the type of tree that develops from the rooted cuttings.

Some of the results of the writer in the propagation of a few other species of conifers and other trees by stem cuttings, made of the most recent year's growth unless otherwise indicated, will now be considered.

Cuttings of eastern red cedar (Juniperus virginiana L.) taken in December usually rooted readily after treatment.

Cuttings of American arbor vitae (Thuja occidentalis L.) taken in fall or winter root well after treatment. It may be of interest to note, as evidence of the variability within the species of a forest tree, that Rehder (loc. cit.) recognized and described thirty forms of American arbor vitae.

Treated cuttings of Atlantic white-cedar (Chamaecyparis thyoides (L.) B.S.P.) rooted very well when taken in November and December.

There is much to commend the Ginkgo (Ginkgo biloba L.) as a possible forest tree, including its relative freedom from natural enemies. The writer took cuttings only from staminate trees. They are easier to live with than the ovulate with its highly malodorous fruits. Cuttings made of apical parts of new shoots rooted well when taken in June and required no chemical treatment. Cuttings made from basal parts of new shoots rooted better if treated. Cuttings were less successfully taken one month later.

Eastern hemlock is not difficult to propagate by cuttings, although there are clonal differences in ability to root. Cuttings in their first year root better than those made of older wood. Treatment with indolebutyric acid is helpful, usually necessary (3). Cuttings of hemlock, if so treated, were successfully taken from August through January. Rooting of hemlock cuttings was further improved by treatment with the fungicide Phygon XL (2,3-dichloro-1)-naphthoquinone). This is one of the fungicides that the writer has been using experimentally with and without a root-inducing substance for the treatment of cuttings. It has also improved the rooting of cuttings of white spruce, white fir, and some other trees (4). Cuttings of Carolina hemlock (Tsuga caroliniana Engelm.) taken in the fall rooted well after treatment with a growth substance.

Untreated cuttings of white fir (Abies concolor (Gord.) Engelm.) have rooted well when taken in late winter.

Cuttings of Norway spruce root fairly readily, and treatment with a root-inducing substance is generally unnecessary. This was true of cuttings taker in the months from November through February. After treatment with a growth substance, cuttings of blue spruce (Picea pungens Engelm.), taken near the end of the dormant period, have rooted well, and there was good rooting of cuttings of white spruce, when cuttings were taken in the fall.

Softwood, summer cuttings of some birches root in fair percentages after treatment.

Softwood cuttings of red maple (Ater rubrum L.) taken in June or July have been rooted after treatment with indolebutyric acid. Snow (17) found that cuttings taken from red maples, the flowers of which are mostly stami-

nate, root better than cuttings taken from trees with flowers that are mostly pistillate. Cuttings from this and other maples should probably be taken as early in the growing season as there is enough new growth to constitute a cutting. In the experience of the writer, this seems to be true of other deciduous trees, hardwoods, which are relatively difficult from cuttings.

Propagation of sugar maple (Acer saccharum Marsh.) by cuttings is being investigated in the Universities of New Hampshire, Vermont, and Massachusetts. If cuttings are taken early in the growing season and treated with a root-inducing substance, some of them will root. But the chief difficulty has been tc keep the rooted cuttings alive during their first winter outdoors or to get them to resume growth the following spring if they are kept in the greenhouse that first winter.

Softwood stem cuttings of American elm (Ulmus americana L.) taken in June rooted well after treatment with a growth substance, not without it (5).

Propagation of forest trees by root cuttings probably deserves more attention than it has hitherto received. Propagation by root cuttings is simple, if and when successful, but digging the roots may be more laborious than taking stem cuttings. In making root cuttings, it is helpful in distinguishing later between proximal and distal ends of cuttings to cut at right angles to the root at the proximal end and to make a slanting cut at the distal end. In work with root cuttings of some species, age of plant from which cuttings are obtained may be a factor, for root cuttings from young plants, e.g., beach plum, may succeed, whereas those from older plants fail.

The Buisman variety of smooth-leaved elm (Ulmus carpinifolia Gieditsch) was readily propagated by root cuttings made in March and set vertically in a greenhouse bench with the proximal end of the root cutting projecting above the surface of the rooting medium (5). If such root cuttings were wholly covered by the rooting medium, a smaller percentage lived.

Shipmast locust (Robinia pseudoacacia L. var. rectissima Raber) was propagated by Swingle (19) by root cuttings. Roots less than one inch in diameter were dug in early spring and planted upright, with the proximal end of the cutting up. A form of honey locust (Gleditsia triacanthos L.) has been similarly propagated by root cuttings taken in the spring (18).

Since some pines, spruces, firs, and other conifers, as well as some hardwoods, may also be propagated by grafting, this method will now be briefly considered. According to some horticulturists, grafted conifers do not develop a perfect leader, but how much evidence there has been for this rather general statement is not clear.

Grafting of conifers has been considered somewhat difficult, and it does require attention to detail, but nothing insurmountable. As in the grafting of other woody plants, the object is to bring into close contact the exposed cambium layers of two plants and hold them until they have united, meanwhile protecting the whole against any drying out. For this a grafting case in a greenhouse may be useful. Involving perhaps more of art than of science, which is nothing against either, the practice of old-time plantsmen has been to transplant to pots in the fall the seedling stock plants, upon which scions of other and better trees are to be grafted, and then to keep them in a cool greenhouse. Two or three weeks before grafting time, which is usually in the winter, it has been considered important to give stock plants a higher temperature so that their roots may make some new growth.

In veneer grafting, stock plants are grown in winter, and scions are taken from dormant trees outdoors. According to horticulturists of long experience, scions should come from the tip or near the tip of the tree to be propagated and should be taken when the temperature is above freezing. The base of the scion is cut wedge-shaped, inserted in or on a cut made near the base of the stock plant and there tied and sometimes waxed. The top of the stock plant remains intact until the union of stock and scion is complete, at which time, four to eight weeks later, the upper part of the stock plant is cut away a little at a time. The grafted plant remains meanwhile in a closed grafting case in the greenhouse.

In the approach method of grafting, the cut surfaces of stock and scion, with both plants still on their own roots are brought and held together. Some nurserymen thus propagate blue spruce, and shortleaf pine (Pinus echinata Mill.) has been grafted by the approach method (8).

Mirov (10) concluded from his work that any species of pine can probably be grafted onto any other species of pine. And this brings up the question of the effect of stock on the subsequent growth of scion, a subject which has for years engaged the attention of pomologists, as it will, probably, increasingly interest foresters who concern themselves with the propagation of forest trees by grafting. Another question, still to be answered, is how do forest trees propagated by grafting compare with those grown from cuttings.

Other trees propagated by grafting include beech, walnut, aspens, maple, and oak. Chase (1) propagated a honey locust by grafting. The cork oak (Quercus suber L.) has been grafted onto several other species of oak (13). Some Japanese maples are grafted, and the so-called sentinel maple (Acer saccharum Marsh. var. monumentale Schwer.) is propagated by nurserymen by grafting. Graves (7) has described a method of grafting by marching or bridge grafting to save the life of diseased chestnut trees. According to Pauley (14), grafting seems feasible for aspens, ashes, and maples, the cuttings of which are difficult to root.

Air-layering, an ancient method of propagating woody plants, has recently been improved and brought to more general attention. Wood of the last season's growth, the branch undetached from the parent plant, is wounded in the spring or early summer, a growth-substance applied, the area wrapped in damp sphagnum, and a film of plastic polythene wrapped around the whole to retain moisture. Wyman (20) described this method by which he was able to induce the development of roots on some species of maple, birch, poplar, and linden but found that the matter of successfully detaching the potential plant from the parent was not easy. Dr. John L. Creech, Superintendent of the Plant Introduction Garden, Division of Plant Exploration and Introduction, U.S.D.A., informs the writer that he has successfully propagated a hybrid larch (Larix eurolepis) by air-layering. It is not a rapid method of propagation, for he has found that with some other species two years may elapse between air-layering and the development of roots.

It is evident that this whole field of investigation, the vegetative propagation of forest trees, is relatively new, and it must be equally evident to foresters accustomed to working with long-lived plants that sometimes years may elapse before final conclusions are drawn.

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