GREENHOUSE GRAFTING OF SPRUCES AND HARD PINES AT THE PETAWAWA FOREST EXPERIMENT STATION

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INTRODUCTION

Vegetative propagation has been used for many years by horticulturists for the multiplication of a great many varieties of fruit trees, shrubs, and ornamentals. It was not until 1936, however, that Dr. C. Syrach Larsen, in Denmark, outlined the use of vegetative propagation in tree breeding. Without the aid of various vegetative propagation techniques the tree breeders would have been forced to use the slow techniques of pure line breeding. Using vegetative propagation, however, it is now possible to (1) facilitate future breeding work by establishing in one place a collection of plus trees which would otherwise be widely scattered and often inaccessible; (2) duplicate any one plus tree in as many plants as required; and (3) under uniform conditions (of soil and climate) rate the plus trees for their relative qualities.

The two methods of vegetative propagation that are of main interest in tree breeding work are (1) propagation by means of cuttings, and (2) propagation by means of grafting.

Frequently seedlings and saplings may be propagated by cuttings, but as soon as the trees reach the flowering stage the rooting of cuttings generally becomes poor. With the exception of some cottonwoods and willows, therefore, old trees usually must be propagated vegetatively by means of grafting. Selected plus trees of spruce and pine usually are mature or overmature. Mastery of the grafting techniques is, therefore, of primary importance in any tree breeding program.

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ROOTSTOCKS

For successful grafting it is important to have fresh, healthy scions and good rootstocks. It is not always possible to secure healthy scions, but it should be possible to produce a sturdy and healthy rootstock of the desired size and shape.

Choice of Rootstock Species

European experience has shown that most spruces can be grafted on Norway spruce (Picea abies (L.) Karst.) and that 2-needled pines should be grafted on 2-needled pines. Only a few experiments with interspecific grafting have been made at the Petawawa Forest Experiment Station, but some observations arise from them.

Spruce

Only Norway spruce and white spruce (P. glauca (Moench) Voss.) have been used as rootstocks, and the following species have been successfully grafted on both: Norway spruce, white spruce, red spruce (P. rubens Sarg.), Colorado blue spruce (P. pungens Engelm.), Serbian spruce (P. omorika (Pancic) Purkyne), oriental spruce (P. orientalis (L.) Link), Koyama spruce (P. Kojamai Shiras), dragon spruce (P. asperata Mast.), and various Sitka x white spruce hybrids. There have been no differences in take or development of these species attributable to the different species of rootstock employed. One attempt to graft black spruce (P. mariana (Mill.) B.X.P.) on Norway spruce failed, probably due to causes other than incompatibility between scion and rootstock.

In routine grafting, sometimes white spruce has proved a better rootstock and sometimes Norway spruce has done so, depending on the timing of grafting and subsequent handling of the grafted plants (see "Grafting Schedule").

Hard Pine

Scots pine (Pinus sylvestris L.) and red pine (P. resinosa Alt,) are used almost exclusively as rootstocks for hard pine grafting, On either species of rootstock the following species can be grafted satisfactorily: Scots pine, red pine, all varieties of P. nigra (Arnold) and Japanese red pine (P. densiflora Sieb, and Zucc.). It is likely that most pines of the group Lariciones may be grafted on these rootstocks.

A number of jack pine (P. banksiana Lamb.), lodgepole pine (P. contorta var. latifolia S. Wats.), and Virginia pine (P. virginiana Mill.), all of the group Insignes, have been grafted on Scots pine rootstocks with normal percent take. Growth of these grafts has not been entirely satisfactory, but it is as yet too early to judge whether Scots pine is a satisfactory rootstock for these species. If not, jack pine would be the preferred rootstock for these species in the group Insignes.

SCIONS

Scions should be taken from the most suitable material, bearing in mind the requirements (which may vary with species) for a good scion, such as length, diameter, the preference for current year's growth, straightness, vigor, and, above all, the existence of at least one bud that will produce a vegetative shoot, Few living trees are so old that branches cannot be found which may be successfully propagated by careful grafting.

Collection of Scions

Most of the scions collected for grafting are cut from branches of mature and overmature trees. The choice of suitable branches from such trees is limited, and great care must be taken with each tree to select the branches that will provide good scions. The scions should always cut longer than the length to be used in order that the propagator may have some latitude when preparing them for grafting.

White Spruce

Usually it is impossible to find current shoots of sufficient length (3 to 5 inches) and quality to form a good scion in the top of a mature white spruce. The reasons are: (1) The weatherbeaten branch ends of old crowns have a short annual shoot growth and are usually much divided with short branchlets at every node. If the branches are thick enough, the propagator can usually cut suitable scions by trimming away small branchlets and grafting back on 3- to 6-year-old wood. However, such scions are regarded as poor material and will usually give a low take in grafting. (2) The branches in the upper part of the crown have often only one end bud, and if this bud happens to be a flower bud it may take many years before the grafted scion develops a vegetative bud. Grafts produced from such scions are useless as it is difficult to trim the rootstock in harmony with the weak scion.

On mature white spruces, the best scions usually can be cut from the lower, more shaded and protected parts of the crowns. By doing some searching, it is often possible to find branches with current shoots that, when cut back on 2- or 3-year-old wood, will provide a scion of reasonable quality.

However, the quality of scions collected from mature trees is generally low compared with those collected from thrifty middle-aged trees or from saplings. On middle-aged trees it usually is possible to find current shoots of sufficient length and thickness to form a good scion. Branches from the uppermost part of the crown are preferred because scions cut from them eventually give grafts of more upright and better form and give a better take (table 1) than do scions collected from the lower branches,

Table 1.--Percentage survival of grafts taken from the upper and lower part of the crown of open-grown, middle-aged trees

Species	Survival when scions are collected from--	
	Upper part of crown	Lower part of crown
Norway spruce	82	75
Red pine	96	80

In practice, branch ends are cut much longer than the length of a scion. For mature trees, whole branch ends up to 18 inches long are Collected and bundled, and later the scions are selected and trimmed by the propagator in the greenhouse shortly before grafting. For middle-aged trees, branch ends 2 to 3 times the length of the scion (about 10 to 12 inches) are collected.

Red Pine

Collection of scions from mature red pine presents only a small problem. Usually the current terminal shoots from the topmost branches of first order are long enough, but they are often too thick to make a perfect match with the rather small, potted rootstocks used in the greenhouse. The terminal shoots of second order are somewhat thinner and thus better suited for greenhouse grafting.

Suppressed branchlets with none or few side shoots, as are found in the lower part of the crown, can also be grafted, but not with as high a percentage take (table 1). These branchlets are grafted on 4- to 6-year-old wood and, therefore, require more care in grafting. The grafts produced with such scions will not grow as vigorously and will demand more skill in handling the first few years than grafts produced from the current year's shoots from the tops of the trees,

Flower buds are no obstacle in pine grafting. The male flowers are formed from the dwarf branch buds which otherwise would develop into needle fascicles, and the female flowers develop from the lateral buds below the terminal bud. In both, the terminal bud will produce a vegetative shoot which is what is required for the satisfactory development of the graft.

The scions should be cut 5 to 6 inches long, about 1/4 inch thick, and preferably from current year's growth.

Jack Pine

Jack pine branches are rather thin. Usually the best scions can be cut from current year's growth of first order branches and preferably in the top of the tree. Suppressed branches in the lower part of the crown commonly are too thin and spindly to produce satisfactory scions.

GRAFTING SCHEDULE

Rootstocks commence growth and reach the graftable stage according to the treatment they are given prior to grafting. This growth rhythm has to be taken into consideration when planning the grafting schedule and for the subsequent handling of the grafted plants. As the growth rhythm is different for spruce and pine, and can be modified considerably according to the time the rootstocks are taken into the greenhouse, the grafting schedule is quite flexible.

Fall Grafting

It is the slight cambial activity of both rootstock and scion that makes it possible to graft in the fall. Ordinarily the temperature during this period is low, but favorable for callus formation which is the main evidence of growth activity. Neither rootstock nor scion starts shoot elongation. By the time growth is stopped by the winter frost, the grafts are sufficiently established to endure the winter. The mastery of the fall-grafting technique is an important contribution to a flexible grafting program, as scions can be collected in the fall when extensive seed collecting trips are made.

Spruce

Spruces have been grafted successfully in August, September, October, and November. As the grafts need a 6-week period to form sufficient callus to carry them through the winter, only the grafts made during August and September may be removed from the greenhouse and placed in cold frames in the middle of November. The grafts made during October and November must be overwintered in the greenhouse. Only Norway spruce rootstocks should be used for late fall grafting as there appears to be a pronounced difference in chilling requirements of the Norway and white spruce rootstocks. White spruces suffer considerably by being kept in the warm greenhouse over winter, and in the following summer show pronounced discoloration of foliage and reduced growth, while Norway spruces retain their healthy appearance.

Chilled fall grafts, besides being of better health, as mentioned above, have better survival than those kept in the greenhouse over winter (table 2). It also appears that early fall grafting is superior to late fall grafting regardless of whether the grafts are chilled or non-chilled.

chilling, as indicated by their unsatisfactory growth and discoloration, and are of doubtful value for winter grafting. Non-chilled Norway spruce rootstocks do not suffer so much from lack of chilling and are therefore better suited to be kept in the greenhouse over winter, In the spring, following grafting, the non-chilled white spruce start to turn yellow while similarly treated Norway spruces retain more of their lush green color. Norway spruce rootstocks give a higher survival than do white spruce.

Hard Pine

Chilled red pine and Scots pine rootstocks should not be grafted too early. It is better to wait until the new growth is in the first stage of shoot elongation. The standard method for forcing red and Scots pine rootstocks is to place the rootstocks in the greenhouse in the early part of winter. After about 6 weeks in the greenhouse the rootstocks come into a stage suitable for grafting. Those taken in on January 15 will be ready about March 1.

It is probable that red pine and Scots pine could be kept in the greenhouse over winter and thus provide rootstocks for grafting from November to March inclusive, These non-chilled rootstocks have a lush, deep green color and almost continuous root and cambial activity. The commencement of shoot growth is much later than for the chilled rootstocks taken in in the middle of January, and the subsequent shoot elongation is somewhat retarded.

Such non-chilled rootstocks have been grafted in November and February-March with good success. On the few grafts made with chilled scions in February-March, it has been observed that the chilled scions grafted on non-chilled rootstocks have stronger shoot growth than similar scions grafted on chilled rootstocks. This has also been found in Dr. C. Heimburger's grafting experiments with white pine in Maple, Ontario.