Hardwood and Softwood Cuttings: Factors Affecting Rootability

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Although propagation of nursery stock by cuttings has become far more efficient there are still problems. The most striking questions relate to the factors that determine rootability in individual cuttings, which lead to variable results even when cuttings are taken from a single source and treated identically. Attempts to find easily identifiable characteristics that would enable propagators to grade out non-rootable cuttings before striking are described.

INTRODUCTION

Research has solved many problems associated with rooting cuttings. The number of taxa which can be rooted and the success rate have both increased, thanks to improved understanding of the environmental requirements for rooting and attention of plant breeders to propagation efficiency. Our increased knowledge of the effects of juvenility have been one of the most important factors in recent improvements in performance as more attention is paid to the effect of age and pruning of stockplants on the rooting capacity of the cuttings. Tissue culture is now used to rejuvenate stockplants and improves the rooting of many taxa.

One of the most significant of remaining problems is the variability of results depending on season, year, mother-stock, growing conditions, cultivars, etc. We still do not know which factors determine the rootability of cuttings in many cases. In practical terms this means it is still difficult to ensure good production planning.

One of the most striking questions is: Why, in a batch of cuttings, some will root and some will not, even under controlled conditions. In our most recent experiments we tried to see if there were any visible or easily measurable characteristics of individual cuttings that would determine their rootability—this would allow growers to grade out any cuttings that would be unlikely to root before attempting propagation.

ROOTING AND CHARACTERISTICS OF CUTTINGS

The rootability of hardwood cuttings is determined mainly by characteristics of the cuttings at the time of harvest. The conditions during the rooting phase are of secondary importance. Hardwood cuttings possess few visible clues about their rootability. Characteristics, such as location on the stockplant or age of the stockplant and thickness of the cutting (Howard and Ridout 1991a, b), do affect rooting. But more endogenous characteristics are needed to predict the rooting results. It is essential to know which characteristics determine rooting and how they can be measured. The level of dormancy (Howard 1981; Kunneman and Otten

1994), the vigour, and juvenility seem to be major factors in rooting.

With softwood cuttings the provision of ideal rooting conditions is more difficult than with hardwood cuttings. Softwood cuttings need light for their development. Therefore, these cuttings are rooted in greenhouses or tunnels where sunlight is available. But with light, problems arise with heat, carbon dioxide supply, and humidity control. Even in climate rooms it is sometimes hard to keep temperature and humidity under control. So the rooting conditions for softwood cuttings may vary from place to place and from time to time. Under such varying conditions it is very hard to ascertain the effect of the quality of individual cuttings on the rooting results. But in softwood cuttings more visible or easily measurable characteristics are available than in hardwood cuttings.

ROOTING OF CONIFER CULTIVARS

Relations between several visible characteristics of individual cuttings and the final rooting results were determined in *Chamaecyparis lawsoniana* 'Golden Triumph', *C. nootkatensis* 'Glauca', ×*Cupressocyparis leylandii*, *Juniperus* ×*media* 'Plumosa Aurea', and *J. virginiana*. The cuttings were rooted under standardised rooting conditions in a mist unit in multicell pots.

The basal 2 cm of each conifer cutting was treated with a solution of 50 or 100 mg $litre^{-1}$ IBA for 8 h. The cuttings were shaded with a 40% daylight screen when natural radiation outside exceeded 120 J m^{-2} s^{-1} and with a 76% screen when the radiation exceeded 170 J m^{-1} s^{-1}. The minimum night temperature was 18C, the minimum day temperature 21C. In all rooting experiments the minimum CO_2 concentration in the air was 800 μl $litre^{-1}$.

After 8 to 10 weeks the rooting percentage, the number of roots per rooted cutting, the fresh weight, and the dry weight of the cuttings were determined.

Any relationships between rooting percentage, root number, and fresh and dry weight of the rooted cuttings with characteristics of individual unrooted cuttings were analyzed by multiple regression analyses. Characteristics of unrooted cuttings were fresh weight, diameter of the cutting, fresh and dry weight of the basal 1 cm of the cutting, the dry matter content of the basal 1 cm of the cutting, the colour of the cutting, and the presence of a visible woody base.

The rooting percentages were: *C. lawsoniana* 'Golden Triumph', 57%; *C. nootkatensis* 'Glauca', 86%; ×*C. leylandii*, 89%; *J.* ×media 'Plumosa Aurea', 68%; and of two batches of *J. scopulorum* 'Skyrocket' 51% and 54%. The rooting percentages for *C. nootkatensis* 'Glauca' and ×*C. leylandii* were rather high and this complicated the search for correlations of rooting with characteristics of individual cuttings. The relations of characteristics with rooting percentage and mean number of roots were limited and cultivar specific. The most general correlations were found between fresh and dry weight after rooting and initial fresh weight of the unrooted cuttings. The initial fresh weight had a strong effect on the fresh and dry weight of the rooted cuttings, except for ×*C. leylandii*. In two conifers there was a negative relation between diameter of the cuttings and characteristics of rooted cuttings.

In related experiments, the number of characteristics with significant effects was limited also for rooted and unrooted cuttings of *C. nootkatensis* 'Glauca' and *J. scopulorum* 'Skyrocket'. Characteristics of unrooted cuttings as fresh weight and fresh and dry weight of the bases of the cutting had high correlation coefficients. In this experiment, too, there was a high correlation between initial fresh weight and fresh and dry weight of rooted cuttings. Also, there was a rather good correlation between rooting percentage and number of roots. Hardly any (very small) correlations existed between rooting percentage and number of roots and characteristics of the unrooted cuttings.

ROOTING OF ENGLISH OAK

In several experiments the regular rooting percentage of English oak (*Quercus robur* 'Gamma') varied from 40% to 60%. This percentage was ideal to determine the correlation of specified characteristics with rooting. Cuttings were taken from stockplants grown in a greenhouse. These cuttings were individually characterized by individual stockplant number, type of twig (short vs. long), type of cutting (nodal cutting vs. top cutting), position of twig on stockplant (base vs. top), number of leaves, diameter of the basal part of cutting, fresh weight, dry weight, and dry matter content (hardness) of basal 1 cm of the cutting.

The cuttings were treated with 0.5% IBA (in talc) and rooted under standard rooting conditions as described above for conifers. The mean rooting percentage of this group of cuttings was 49.6%. The number of the stockplant and the initial fresh weight of the cuttings ($p<0.05$), distance to shoot tip, diameter, and length of the shoot ($p<0.01$) affected rooting percentage significantly. The best rooting was obtained with short thin shoots from the basal part of the stockplant. However, there was no single measured characteristic which determines rooting to a great extend.

Table 1. Effect of shoot position (base-top), shoot type (short-long), and type of cutting (nodal-tip) on rooting percentage of *Quercus robur* 'Gamma' cuttings.

		Nodal	Tip	Mean	Gr. mean
Base	Short	86	62	67	63
	Long	47	68	60	
Top	Short	56	52	53	44
	Long	33	48	35	
Mean	Short	65	57	59	
	Long	38	53	45	
Gr. mean		43	55		49

[1]Unequal numbers of cuttings per treatment.

Correlation of characteristics with rooting was moderate. Only combinations of more than one characteristics had strong relations with the rooting percentage. Rooting of 86% could be obtained when selection of the cuttings was based on position, type of twig, and length of the twigs. Table 1 shows the combined effect of these three characteristics.

CONCLUSIONS

It was difficult to relate visible or easily measurable general characteristics of unrooted cuttings to rooting results. In winter cuttings the level of dormancy is related to rooting. In softwood cuttings relations between characteristics and rooting percentage and root number are limited. Characteristics seem to be cultivar specific.

To relate rooting to previous measured visible characteristics was difficult. The first problem was to determine which visible or measurable characteristics could be used. There was no general relation with rooting percentage and root number. Relations of weight before rooting and weight after rooting were general. This means that the quality of the cuttings and the regrowth can be improved by increased initial fresh weight. Initial fresh weight can also be used to sort the cuttings to improve the uniformity after rooting.

The second problem was the effect of rooting conditions on the relationship between characteristics and rooting. The relationships varied depending on whether cuttings were rooted under mist, fog, or polyethylene (data not shown).

The third problem was that several characteristics were not independent. This influenced the analysis of the relationships. For example all characteristics based on weight correlate with each other. However, thicker cuttings generally have a higher weight than thin cuttings, and the weight of cuttings with more branches is higher. This means that all relationships between rooting and every single characteristic have to be analyzed to see which have the best correlation.

The fourth problem was that certain combinations of characteristics, which individually have only a minor correlation with rooting, work synergistically—they have a greater effect when working together than you would expect.

In hardwood and softwood cuttings the endogenous levels of enzymes, growth substances, and/or carbohydrates (Veierskov, 1988) might have a more significant relationship with rooting than visible characteristics. Searching for such characteristics is one of the major tasks for future research.

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