Ann Sci For (1993) 50, Suppl 1, 351s-355s

Original article

Grafting of oaks with variegated leaves

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Summary — Among 1-year *Quercus robur* L seedlings, several plants were selected, differing from others in the population by their variegated leaves. Such plants could be useful in arboriculture, if we could fix the appearance of variegated leaves and solve the problems of vegetative propagation. This paper discusses the cytoplasmic inheritance of oak leaf variegation and describes the methods of grafting. Grafting and callusing of grafts in a mixture of sawdust and moss enables the production of an average of 32% firmly joined grafts at the end of the first growing season.

***Quercus robur* L / leaf variegation / vegetative propagation**

Résumé — Greffage de chênes aux feuilles bigarrées. *Plusieurs plants d'un an de* Quercus robur *L présentant des feuilles bigarrées ont été sélectionnés. Ces plants pourraient être utilisés en horticulture, si les problèmes de fixation du caractère bigarré et de multiplication végétative sont résolus. Cet article discute de l'hérédité cytoplasmique du caractère bigarré et présente une méthode de greffage. Le greffage et la cicatrisation de la greffe dans un mélange de sciure et de mousse permettent d'obtenir 32% de greffes fermement adhérentes aux porte-greffes à la fin de la première saison de végétation.*

Quercus robur *L / feuilles bigarrées / multiplication végétative*

INTRODUCTION

Among the numerous pedunculate oak seedlings in our nurseries, individual specimens with differently variegated leaves are noticeable. We have selected 50 genotypes since 1987, with the aims of monitoring foliar changes throughout the season and propagating the best variants by the device grafting method used by Borzan and Littvay (1989). In addition to our own selected oaks, we have collected variegated samples from the Kilmacurragh Institute in Ireland. This paper discusses the foliar variegation of pedunculate oak leaves based on the available literature and presents the results of their vegetative propagation.

MATERIALS AND METHODS

The behavior of figurative patterns of foliar variegation of 50 selected pedunculate oak seedlings has been monitored in the nursery since 1987.

Scions from 5 of our own oaks and 4 from trees at the Kilmacurragh Institute in Ireland (table I) were kept in the refrigerator (+ 5 °C) and grafted. Grafting was carried out in March 1991, using a home made grafting device fixed to a table and powered manually. The device cut a groove on the root-stock and a cog on the scion in the shape of the Greek letter Ω (fig 1). Joined root-stocks and scions were kept for 14 days in a box completely covered by a mixture of wet, fine and coarse sawdust (75%) and moss (25%) at a stable temperature of 27 °C and an air humidity of 70–80%. After 14 days, the callused and flushed grafts were taken out, planted in containers, put in the shade in a heated plastic house and protected both from spring frosts and strong sunlight. The remaining grafts were returned for further callusing for another 7 days.

RESULTS

Among 50 selected 1-year-old seedlings with differently variegated leaves in the course of the 2nd and 3rd year, some of them changed to green leaves, indicating a loss of variegation.

A small number of plants (5) showed the same type of variegation on all leaves both in the 2nd and 3rd year (fig 2a, b, c). Two of them had second-flush leaves with larger variegated surfaces (fig 2b, c), thus differing from those of the first flush.

Most of the plants (20) remained variegated in the second and subsequent years but with only occasional variegation of their leaves. Some produced green leaves in the first flush and variegated ones in the second (fig 2d), while others did the opposite. Among the latter group, 1 plant produced only white leaves in the first flush and green in the second. Soon after the appearance of green leaves on that plant, the white leaves fell, after becoming brownish.

Table I. Results of device grafting of variegated pedunculate oak.

Cultivar (ortets)	*Grafted*	*Successful grafts*	
	(n)	*(n)*	*%*
Q robur Zagreb 1	17	11	65
Q robur Zagreb 2	3	2	67
Q robur Zagreb 5	2	1	50
Q robur Zagreb 6	7	0	0
Q robur Zagreb 7	6	2	33
Q robur Ireland 1	30	7	23
Q robur Ireland 2	25	11	44
Q robur Ireland 4	8	1	13
Q robur Ireland 5	15	1	7
Total	113	36	32

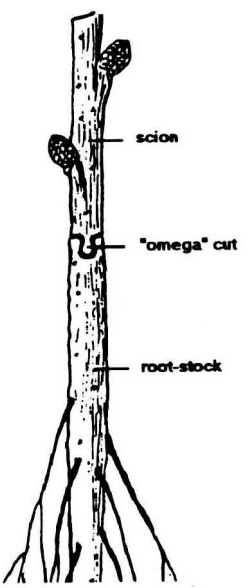

Fig 1. Schematic display of joined root-stock and scion, made by using the grafting device.

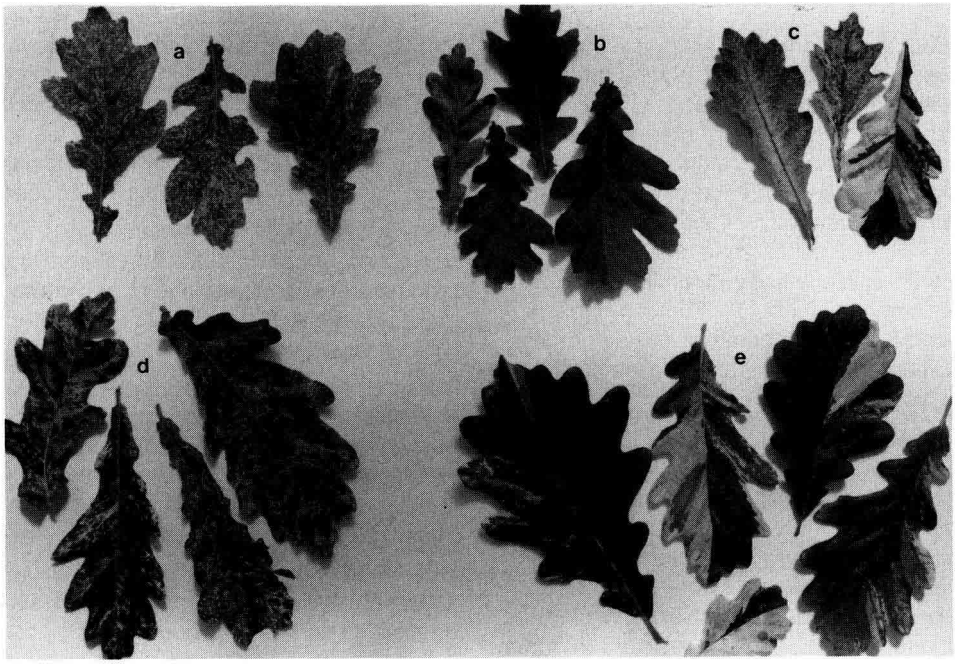

Fig 2. Patterns of variegated second-growth leaves of 5 different *Q robur* L genotypes.

One of the 5-year-old plants had a strongly variegated side branch though no variegated leaves occurred on the main stem. The variegated branch also had a certain number of completely green leaves.

Generally, the spring types of variegation are more attractive than the summer ones, showing brighter white and yellow colors. In summer, individual variegated parts of the spring leaves dry, especially if the plants are exposed to the sun.

Table I shows the results of grafting. Out of the 113 plants grafted on 27 March 1991, 36 had developed normally by mid-August, *ie*, 32% were considered fairly successful.

Grafting success depended primarily upon the thickness of the scion, because it is much easier to perform regular "omega" cuts on thicker scions. The plants with short and thin shoots gave poorer results. Some grafted genotypes that were expected to have variegated leaves produced only green leaves throughout the season.

These results support our previous findings (Borzan and Littvay, 1989) when we concluded that it was possible to graft pedunculate oak successfully and to recommend device grafting as a simple and low-cost method.

DISCUSSION

Variegation was defined by Schultz (1936) (quoted by Rieger *et al*, 1976) as "... the occurrence, within one tissue, organ, or in-

dividual, of a mosaic phenotype with respect to pigmentation... It is a widespread phenomenon caused by several (observed or inferred) mechanisms: 1. Plastid variation and the behavior of plastid variants in somatic divisions of plants; 2. Genic instability and the recurrence of somatic mutations; 3. Instability of the phenotypic expression of genes as a result of position effect; 4. Genetically controlled stickiness of chromosomes; 5. Somatic crossing-over; 6. Somatic behavior of ring chromosomes and dicentric chromosomes; 7. Infection".

All of these causes of oak leaf variegations are probably present in our plants, except the last. Variegated oaks change rapidly up to the age of 3 years. Usually, after the 3rd year, their variegated features become increasingly stable, while the sorting of mutated plastids is very intensive during the first 3 years, resulting in some plants eventually having only green leaves.

However, the heritable properties of the plastids (the sum total of the extrachromosomal genetic information is defined as plastom, after Renner (1929, 1934) (cited in Rieger *et al,* 1976) *ie*, their ability to mutate and to multiply are of importance for the expression of variegation. Tilney-Bassett (1963) considers variegated plants to be chimeras.

We have observed 2 main kinds of foliar variegations among selected pedunculate oak seedlings.

Stable variegations (fig 2a, b, c) which are most probably controlled by nuclear genes, causing mutations of 2 kinds. First, those with variegated leaves, produced at each flush, having different shades of green, yellow, cream or white or combinations of these colors evenly distributed through the whole leaf (fig 2a). Such features resemble the foliar variegation of *Dieffenbachia maculata* cultivars Perfection and Hoffmannii, for which Henny (1982) concluded that their foliar variegation is under the control of a single dominant nuclear gene. This assumption can only be proved after spontaneous or induced flowering of these variegated oak seedlings, when it is possible to perform controlled crossing.

Second, those with foliar variegations produced at each flush (fig 2b, c), with the leaves of the first flush having a different type of variegation than those of the second.

Stable variegations are most desirable, because of their beauty and promise for tree improvement work. The slower growth of our specimens of this kind is, at the moment, a disadvantage because at 5 years they are still too small to be grafted.

Occasionally variegated oaks can also be divided into two groups. First, those with green leaves on the first flush and variegated ones on the second, or *vice versa.* Variegation of this type is quite stable, *ie*, foliar variegation appears every year only on the first-flush leaves or only on the second flush leaves. The extent of the variegation on branches varies. Thus, it is advisable to mark the branches with attractive and extended leaf variegation during a season and to use them as scions the following spring, to assure a greater quantity of mutated plastids in grafted plants.

The nature of this type of variegation is not clear at the moment. It is probably caused by nuclear gene-induced plastom mutation with increased variegation frequency only at a certain time during the season (*ie*, only in a certain tissue layer of cells), for variegation appears repeatedly at a particular time during the growing season, while during the rest of the season the plant flushes with only green leaves.

Second, occasionally variegated oaks can have foliar variegation as sports. Variegation of this type could be lost. Such

plants have several features. At least during the first part of the season, variegated leaves have large, nicely colored yellow–green or white–green patterns which may appear every year and remain stable. Often, white or yellow leaf parts shrivel and burn in full sun. It is advisable to raise them in half shade. However, sports are interesting for possible vegetative propagation.

Occasionally variegated oaks grow faster than those with stable variegated leaves.

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