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Original article

Influence of fertilized substrate on rooting and growth of oak cuttings

W Spethmann, P Harms

Institüt für Obstbau und Baumschule, Universität Hannover, Am Streinberg 3, 3203 Sarstedt, Germany

Summary — A system for bulk propagation of *Quercus robur* and *Q petraea* by cuttings has been developed. Rooting percentage and shoot growth could be improved by fertilizing the rooting substrate with Oscomote. After overwintering, rooted cuttings could be planted directly in the forest. Survival was much better than that of cuttings cultivated for 2 more years in the nursery. These 1-year-old cuttings were produced more cheaply than seedlings.

cuttings / *Quercus petraea / Quercus robur* / fertilized substrate / slow-release fertilizer

Résumé — Effets de substrats fertilisés sur l'enracinement et la croissance de boutures de chênes. *Une méthode de multiplication en masse de* Quercus robur *et de* Q petraea *par bouturage horticole a été mise au point. La fertilisation du milieu par l'Osmocote améliore l'enracinement et la croissance des boutures. Elles peuvent directement être plantées en forêt au printemps suivant leur enracinement. Leur survie et leur croissance sont meilleures que celles des boutures ayant séjourné deux années supplémentaires en pépinière. Leur coût est également moins élevé que celui de plants issus de semis.*

boutures /* Quercus petraea / Quercus robur */ substrat fertilisé / engrais à diffusion lente

INTRODUCTION

Cutting propagation of oak is said to be quite difficult. Singular good results could not be repeated in numerous investigations. Cornu *et al* (1977) and Garbaye *et al* (1977) were the first to obtain good results continuously by using a fog system. But further cultivation and especially overwintering were difficult and too expensive for large scale propagation.

Based on this fog system, a bulk propagation method was developed at the Lower Saxony Forest Research Institute in Escherode (Spethmann, 1986). The following 4 parameters were found to be critical. 1) Decreasing mother plant juvenility limits the success of the propagation. With increasing age, rooting and root number decrease, and callus formation increases. Losses during and after the first overwintering increase rapidly, further growth stagnates or slows down (Spethmann, 1990). Seedling age of 6–7 years limits successful and profitable propagation. By cutting back the mother plants every March to 5–20 cm juvenility could be maintained for more years, and a good rooting percentage was obtained. Nowadays 9-year-old cut-back mother plants are used without decreasing of rooting. 2) Inserting time is limited to 3 weeks in June, dependent upon the physiological stage of the new growth. The best time is when the leaves were still light green but already full developed. 3) Only rooting under the continuously high humidity of a fog system secures replicable success. 4) Successfully overwintering up to 95% of the rooted cuttings is only possible when retaining the rooted cuttings in the rooting bed in an unheated greenhouse. Calculation of all cost results in a price of 0.50 DM/rooted cutting which is less than that for a 1-year-old seedling.

Rooted cuttings have a mean height of 15–20 cm. If too small, they are often lost during nursery transplanting and weeding. After 2 additional growth periods in the nursery which are necessary to produce plants large enough for afforestation, *Q petraea* had a height of 50–60 cm, and *Q robur* of 40–50 cm.

To shorten the time until transplanting in the forest, we have experimented with application of fertilizers to the rooting substrate to produce better shoot growth and reduce the time required in the nursery.

MATERIALS AND METHODS

Investigations were conducted 1988 at the district forest station Delliehausen. The investigation was integrated in a practical mass propagation of 38 000 oaks. Cuttings 10–15-cm long of *Quercus petraea* and *Q robur* from 3–5-year-old mother plants were harvested during the period 1–13 June, the lower leaves were stripped and the cutting base dipped in 0.5% IBS (in talc) + 10% Euparen. An area of 2.5 m^2 each was used for the fertilization of the substrates with 9 concentrations of the slow-release fertilizer Osmocote Plus (N:P:K:Mg, 15:11:13:2, 3–4 mo) and 5 concentrations of the quickly soluble Nitrophoska Spezial (12:12:17:2) (table I). The fertilizer was mixed with the upper 30cm of the substrate. Another 2.5 m^2 beside each plot remained unfertilized as a control; that was necessary because of different provenances and because the 2 oak species were inserted one after another.

In a film greenhouse (10 x 20 m) one-half of the ground bed is filled with gravel (3–8 mm), the other half with a mixture of peat:sand:perlite: styromull (1:1:1:1). 650 cuttings were set in each of the 2.5 m^2 plots. So 18,200 cuttings were planted in fertilized and also 18,200 cuttings in unfertilized substrate. A high-pressure fog system (Norrison) controlled by a hygrostat was used to maintain high air humidity and a mist system to water the substrate when necessary. There was no bottom heating. The greenhouse was shaded and remained closed even when the air temperature went up to 50 °C. Rooting started after 3 weeks. In September the cuttings were hardened by reducing air humidity and ventilating the greenhouse. The cuttings remained in the rooting bed and were evaluated 4–6 April. For rooting percentage, all 650 cuttings were used. For evaluating root number, root length, and shoot length, only a random sample of 100 cuttings were used. After the measurements, cuttings were transplanted to the nursery, a small number of 260 *Q petraea* cuttings (0 + 1) were directly planted in the forest together with cuttings from 2 years' cultivation in the nursery (0 + 1 + 2) (Müller, 1991).

Table I. Fertilization treatments in g of fertilizer per liter of medium.

Osmocote (g/l)	*Nitrophoska (g/l)*
0.0	0.0
0.5	0.5
1.0	1.0
1.5	1.5
2.0	2.0
2.5	–
3.0	3.0
3.5	–
4.0	–
6.0	–

RESULTS

Mean rooting percentage was 59%, 19% were unrooted, 22% had formed a callus. Osmocote in gravel did not influence rooting. Osmocote in peat:sand increased rooting especially at concentrations of 0.5 – 2.5 g/l. At 2.0 and 2.5 g/l, the increase was highest (fig 1). Nitrophoska had a similar effect. In gravel only a slight increase was observed, in peat:sand from 1.0–3.0 g/l the stimulating effect increased (fig 2).

Root number and root length were not influenced by any fertilizer treatment.

Shoot length was increased by Osmocote in gravel and peat:sand. Mean height in gravel was 16.5 cm, fertilized 21.5 cm. Mean height in peat:sand was 16.1 cm, fertilized 22.3 cm. But in gravel no effect to concentration was found (fig 3). In peat: sand growth increased by all fertilizer treatments. With fertilization > 2 g/l, mean increase was > 7 cm (fig 4).

Nitrophoska treatments showed no effect on growth.

DISCUSSION

Fertilization of the rooting substrate is said to decrease rooting due to the negative effect of salt concentration (Sörensen and Coorts, 1967; Wott and Tukey, 1973; Hartmann and Kester, 1983). However, many investigations with slow-release fertilizer show a positive effect on rooting percentage and shoot growth (Schulte and Whitcomb, 1973; Richards and Whitcomb, 1980; Przeradzki and MacCarthaigh, 1988).

In this experiment, the rooting percentage increased with the Osmocote concentration up to 2.0–2.5 g/l and then decreased. With Nitrophoska, higher concentrations were required probably because the soluble Nitrophoska was leached. Low concentrations of fertilizer salts improve the rooting percentage.

In contrast to other investigations, root parameters were not affected by fertilization.

In both tested substrates, small amounts of Osmocote (0.5–1.0 g/l) in-

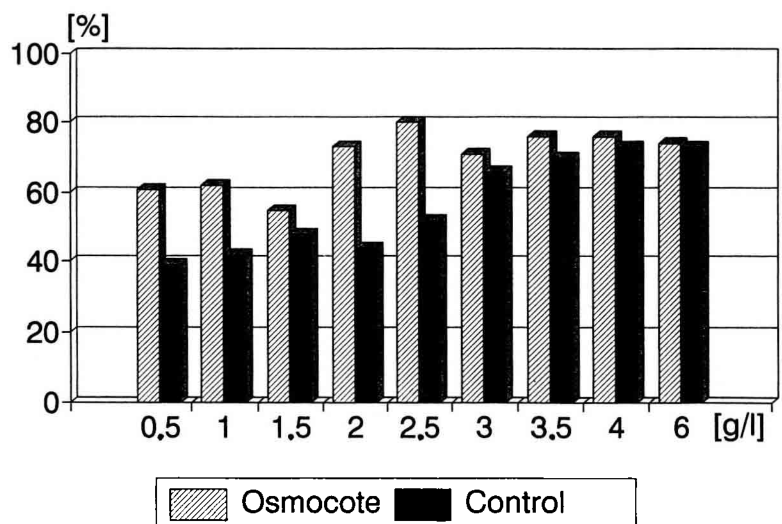

Fig 1. Rooting percentage in peat:sand as influenced by Osmocote (means of 650 cuttings/treatment).

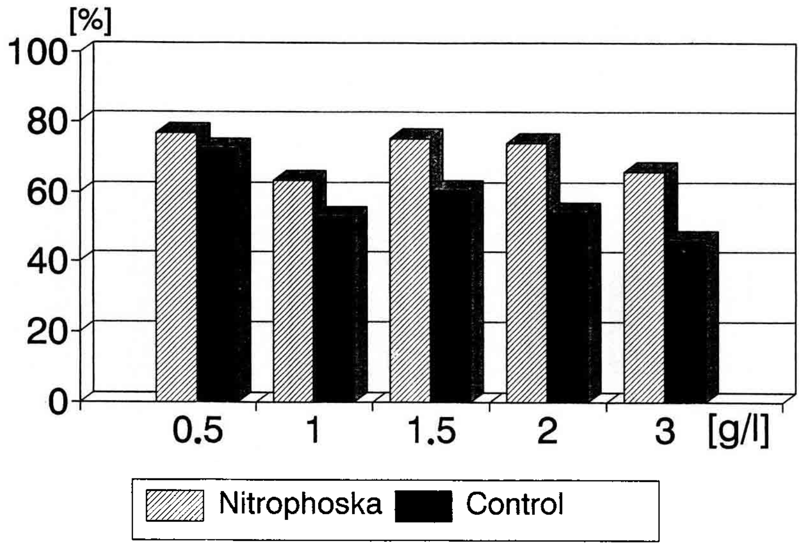

Fig 2. Rooting percentage in peat:sand as influenced by Nitrophoska (means of 650 cuttings/treatment).

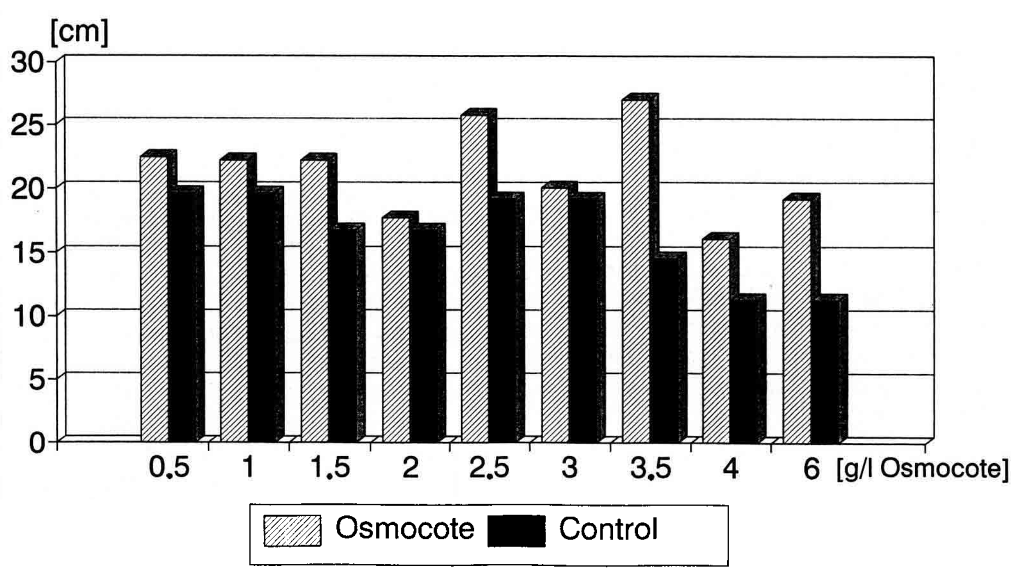

Fig 3. Shoot length as influenced by Osmocote in gravel substrate compared to control (means of 100 cuttings/treatment).

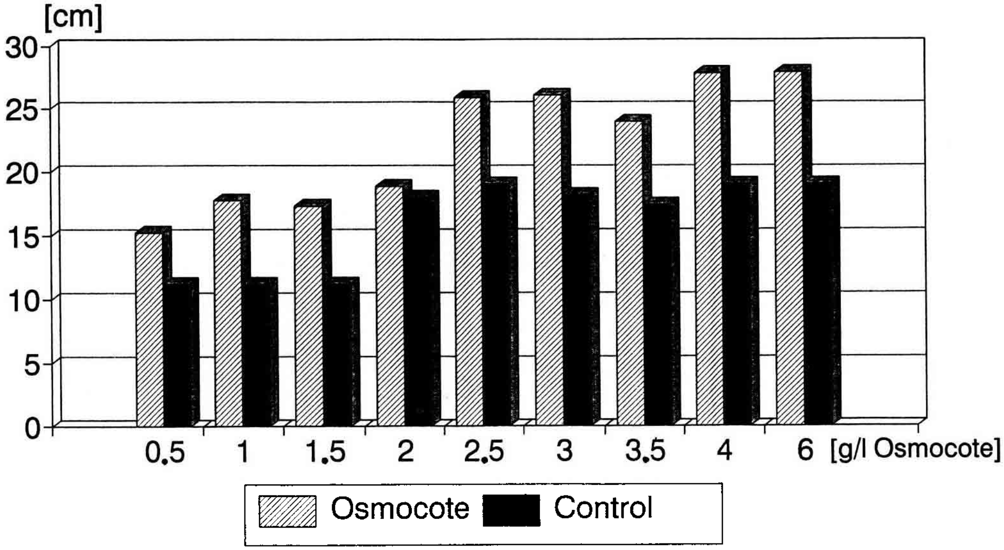

Fig 4. Shoot length as influenced by Osmocote in peat:sand substrate compared to control (means of 100 cuttings/treatment).

creased shoot growth. Higher concentrations gave no increase in gravel; in peat:sand, further increase of growth was only small. Hamilton and Johnson (1978) demonstrated the decreasing availability of NO_3^- because of its absorption to the substrate. Optimal availability of NO_3^- was found at pH higher than 5.5. In April in Delliehausen, the pH was 7.2 in peat:sand, and 6.4 in gravel. With increasing levels of Osmocote, the pH decreased to 6.5 in peat:sand and to 5.5 in gravel. The same acidifying effect of Osmocote was found by Sanderson (1987).

To determine the optimum addition of Osmocote, its effects on rooting and shoot growth should be considered. But high concentrations should be avoided to reduce leaching of NO_3^- into the ground water.

For improvement of mass propagation of oak, the addition of low levels of Osmocote 1.5–2.5 g/l is recommended. pH should be > 5.5.

This investigation also explored whether it is possible to reduce production time of oak cuttings. In April 1989, from the above plants some hundred selected *Q petraea* cuttings with mean height of 51 cm (gravel) and 42 cm (peat:sand) were directly planted in the forest together with cuttings after 2 years' cultivation in the nursery, mean height 65 cm (gravel), 50 cm (peat:sand). In autumn 1990, survival was evaluated (Müller, 1991). Only 1/3 of the older cuttings, rooted in gravel and peat:sand, respectively, survived. Young cuttings rooted in gravel had a survival of 73%; 94% of the cuttings rooted in peat:sand survived.

In a second field trial, Müller (1991) also compared cuttings with seedlings. *Q petraea* cuttings (0 + 1 + 2) were planted in the spring of 1987, in comparison to seedlings (2 + 2), and were measured at the end of 1990. Mean height of cuttings rooted in peat:sand was 127 cm, that of the cuttings rooted in gravel was 122 cm. The seedlings 1-year-older than the cuttings had a mean height of only 109 cm. Seedlings and cuttings were from the same provenance. Evaluation of the plant habit in 1990 showed the same differences as height. Cuttings from peat:sand had 80%, gravel 69% and seedlings 55% normally formed plants (Müller, 1991).

The results showed that vigorous oak cuttings with good performance after plantation in the forest may be produced in 1 year. That would reduce production costs below the seedling price. On the other hand, it is possible to react very quickly to missing or low crops of acorns by increasing oak cuttings production.

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