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Survival and growth of planted and seeded oak (*Quercus robur* L.) seedlings with and without shelters on field afforestation sites in Finland

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Abstract

The study focused on the initial development of oak (*Quercus robur* L.) seedlings on former agricultural fields with or without treeshelters. Additionally, planting and direct seeding were preliminary compared in terms of a parallel small-scale seeding trial. The influence of treeshelters was examined using 120-cm-high polypropylene tubes. Initial success was assessed in terms of average survival rate and seedling height during a 5-year-period after establishment. The study was based on 8 experimental plots, with 3 sheltering treatments (100, 50 and 0% of the seedlings sheltered). A set of seeding plots were established adjacent to the planting experiments. The average survival rate for the planted seedlings was 75–83%. Sheltering had accelerated the height growth of the planted oaks substantially (average height was 60 cm for 0% sheltered, 82 cm with 50%, and 101 cm for 100% sheltered). The sheltered and unsheltered seedlings in the 50% treatment exhibited growth and mortality similar to the 100 and 0% treatments, respectively. The seeded seedlings were much smaller (average 34 cm) and their combined emergence and survival rate (average 56%) was lower than the survival rate in planting. Since the seeding plots did not belong to the same block design as the planting treatments, differences between seeded and planted seedlings were not statistically tested. The seedlings in all treatments were subjected to rapidly increasing competition by the remarkably proliferating weed vegetation, resulting in poor growth and vigor, and high mortality rate in direct seeding but much less so in planting. With an unexpectedly low incidence of herbivory in the study stands, the survival rate of unsheltered seedlings was not significantly lower than that of sheltered seedlings.

Keywords: Afforestation; Planting; *Quercus robur*; Seeding; Treeshelters; Weed control

1. Introduction

Common oak (*Quercus robur* L.) occurs in scattered natural distribution in southernmost Finland (Ollinmaa, 1952). Prior to human influence in natural conditions, oak was probably much more common than today. Natural oaks have been repeatedly harvested, and many fertile oak sites have been converted to agriculture long ago. Oak has also been grown as solitary trees, groups, and small stands within and outside its natural range in the country, mostly for amenity and cultural values (Ollinmaa, 1952). Its use in commercial forestry has been limited to very few small experimental, often poorly managed plantations, but the potential seems greater (Valkonen et al., 1995, 2002).

However, the interest in oak has increased among environmentally conscious landowners and forest and park managers. A few prime examples of intensively managed stands indicate that it is possible to grow oaks into valuable products through purposeful management in Finland (Valkonen et al., 1995, 2002). Oak and other rare broadleaved tree species provide habitats to many threatened specialized species. Large oaks are an important feature of the rural landscape in southern Finland. Afforestation of former agricultural lands with broadleaves is often seen as an ecologically and socially preferable alternative to conifers (Löf et al., 2004). The promotion of rare broadleaf species, which have been greatly reduced by human activity in the past, is often seen as a particularly beneficial practice in this respect. Former fields often constitute favorable sites for the demanding species, as their fertility level is generally higher than that of regular forest sites (Well and Hytönen, 2005).

A survey study on young (1–15 years old) planted oak stands indicated better than expected results for afforestation projects on former farmland in southern Finland (Valkonen et al., 1995). The average mortality (12%) was about the same as for Norway

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spruce (*Picea abies* (L.) Karst.) in field afforestation (12% within 5 years) but substantially smaller than that of silver birch (*Betula pendula* Roth) (37%) and Scots pine (*Pinus sylvestris* L.) (36%) in contemporary afforestation projects (Ferm et al., 1993; Hytönen, 1995; Valkonen et al., 1995). However, the average stocking was just 1130 stems ha^{-1} since only 1300 stems ha^{-1} had been planted. The proportion of oaks damaged by herbivores was only 22%. Tree shelters (polypropylene tubes of 60–120 cm height) were used in 60% of the stands. 84% of the oaks were completely healthy or showed only insignificant signs of damages or lowered vitality. Despite their low damage and high vitality rates, the oaks had grown much slower than birch and pine seedlings (which are fast-growing pioneer species) on field afforestation areas as reported by Ferm et al. (1993), and even somewhat slower than spruces (which is a slow-starting shade-tolerant species).

Planting of oak in Scandinavia is a costly operation, regularly involving higher planting densities (up to 4000–6000 ha^{-1}), tree shelters, and weed control. The establishment costs tend to range between €3000 and 7000 ha^{-1} (Madsen and Löf, 2005) without fencing, which is often necessary and can raise the costs substantially. Due to its small demand, planting stock of oak for reforestation or afforestation purposes is more expensive in Finland (around €1) than in southern Scandinavia for example, which makes the operation even more costly. Generally, the establishment costs for the ordinary species alternatives (e.g. spruce and birch) for fertile sites are very low in comparison (around €1000–1200 ha^{-1}). It is thus understandable that the results of economic calculations hardly encourage the forest owner to choose oak for reforestation or afforestation in the Nordic countries (Eriksson, 1991). However, rather generous subsidies have been paid to forest owners from time to time to use those species, particularly in Sweden. Furthermore, it is compulsory by law to use elm (*Ulmus glabra* Hudson, *U. laevis* Pallas), ash (*Fraxinus excelsior* L.), hornbeam (*Carpinus betulus* L.), beech (*Fagus sylvatica* L.), oak (*Q. robur* L., *Q. petraea* (Mattuschka) Liebl.), wild cherry (*Prunus avium* L.), lime (*Tilia cordata* Miller), or maple (*Acer platanoides* L.) to reforest stands of those species after harvesting in Sweden.

Using admixtures with species with cheaper planting stock and no need for individual tree shelters is one possibility to reduce costs while retaining sufficient density (Rainio, 1986; Tyystjärvi, 1994; Uusvaara, 1996; Madsen and Löf, 2005). However, the management of two species with different growth rates is often complicated, particularly when spruce is involved (Almgren et al., 1984; Rainio, 1986; Valkonen et al., 1995). Various spatial distributions based on row or group patterns have been suggested as a solution but often with little experience or empirical data (Almgren et al., 1984; Tyystjärvi, 1994; Uusvaara, 1996).

Direct seeding of oak is an old, established method in the southernmost part of Scandinavia (Denmark and Scania, Sweden). It has attracted renewed attention in recent years as a potentially cheaper alternative in other regions as well (Löf and Möller-Madsen, 1997; Löf and Madsen, 1998; Löf et al., 2004; Madsen and Löf, 2005). Based on Central European tradition, it has often involved large quantities of acorns (Löf and Madsen, 1998) for mutual protection and better morphology of the seedlings. There is very little experience on direct seeding of oak under Finnish circumstances. Good quality acorns of suitable provenances are not readily available in such large amounts and to low prices as in Southern Scandinavia. Direct seeding with low initial densities seems an interesting low-cost alternative, but there are potential problems that require attention. Acorn predation from rodents in particular tends to constitute an additional element of risk in direct seeding compared to planting (Nilsson et al., 1996; Löf et al., 2004; Madsen and Löf, 2005). Placing the acorns at greater depths (5–10 cm) in the soil has been tried as a possible prevention with substantial benefit (Johnson, 1981; Nilsson et al., 1996). However, germination and seedling emergence may be encumbered particularly on heavy clayey soils. One solution is to use external lighter textured, sandy material to cover acorns (e.g. Löf et al., 2004; Madsen and Löf, 2005). Protection of acorns with mini-shelters (polypropylene tubes, height 25 cm, diameter 2.8 cm) has been experimentally tried but does not seem attractive (Löf et al., 2004; Madsen and Löf, 2005). Weed competition can be a more serious problem in direct seeding than in planting, where the 1–2-year advantage in size and growth potential of the plants may constitute a decisive advantage over the herbaceous vegetation and grasses, particularly on former farmlands (Nilsson et al., 1996; Madsen and Löf, 2005). In addition to the direct influence on seedling vigor and growth through increased resource availability, weed control also tends to substantially reduce rodent damage in afforestation of farmlands under Finnish conditions (Ferm et al., 1994; Hytönen and Jylhä, 2005).

In the face of limited acorn availability, high planting, protection, and tending costs, and unknown revenue potential, it seems clear that low-cost methods for oak cultivation are needed with particular urgency in Finnish forests. Rather low planting and seeding densities with high seedling emergence and survival probabilities seem one of the key features. On the other hand, greater investment in post-establishment care would be required to ensure survival, rapid growth, and good form of seedlings and saplings.

Tree shelters are known to greatly enhance the growth rate of oak seedlings and to effectively protect them against small rodents at their most susceptible initial stages, thus substantially improving the initial survival rates (Lantagne, 1991; Potter, 1991; Minter et al., 1992; Walters, 1993; Uusvaara, 1996). Their instability and ice buildup in temperatures varying around the freezing point and with variable forms of precipitation seem to constitute major problems in Finnish forests. Their high purchase, setup, and maintenance cost (in terms of money and labor) tends to raise the question whether it would be possible to achieve satisfactory results with partial or no sheltering.

The objectives of the study were to examine

- the general initial success (survival rate, seedling height) of planting oak on former agricultural fields;