Abstract

This study examines how innovative peat-free substrates and different fertilization regimes affect the early growth of container-grown *Fagus sylvatica* L. and *Quercus robur* L. seedlings. Focus was placed on above-ground biometry, root system traits, and biomass–nutrient allocation. Seedlings were cultivated in conventional peat-based substrate and three innovative peat-free substrates (R20, R21, R22), each combined with either traditional solid fertilizer (as used in Forest District Daleszyce) or novel liquid fertilizer developed by the University of Agriculture in Kraków. The materials were developed under the NCBiR-funded POIR.04.01.04−00−0016/20 project, led by Prof. Stanisław Małek. After nursery cultivation, seedlings were planted in Miechów Forest District, and evaluated a year later. Solid fertilizer consistently led to better growth performance across species. Among the substrates, R22 showed the closest growth results to peat, particularly with solid fertilizer. Although peat-free variants supported good survival, shoot and biomass growth varied with species and treatments. Root morphological analysis indicated strong effects of substrate-fertilizer interactions. In beech, very fine roots traits (≤ 0.50 mm) correlated with shoot growth, suggesting a surface-oriented, phototropic strategy. In oak, total root length was more predictive of shoot development, reflecting a deeper, gravitropic strategy. Nutrient allocation patterns showed species-specific responses. Peat and R22, especially under solid fertilization, promoted higher N, P, and K accumulation. Very fine roots were critical for above-ground growth in beech but less so in oak. The results stress the importance of species-specific nursery protocols. Peat-free mixes like R22 are promising for sustainable forestry, but fertilization optimization remains key. The findings offer practical insights for climate-smart reforestation and environmentally conscious nursery practices.

Keywords: forest establishment, biometric traits, peat-free substrates, seedling survival, nutrient allocation, root diameter classification

Odunayo James Rotowa

Krakow, 12th May, 2025