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Estimation of biological nitrogen fixation by black locust in short-rotation forests using natural 15N abundance method

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The importance of short rotation forests and agroforestry systems for woody biomass production for bioenergy will increase in Central Europe within the next decades. In this context, black locust (Robinia pseudoacacia) has a high growth potential especially at marginal, drought-susceptible sites such as occur in Brandenburg State (Eastern Germany). As a pioneer tree species black locust grows under a wide range of site conditions. The native range of black locust in Northern America is classified by a humid to sub-humid climate with a mean annual precipitation of 1020 to 1830 mm. In Central and Eastern Europe, this species is cultivated in a more continental climate with an annual precipitation often below 600 mm. Therefore, black locust is known to be relatively drought tolerant compared to other temperate, deciduous tree species. Because of its N2-fixation ability black locust plays generally an important role for the improvement of soil fertility. This effect is of particular interest at marginal sites in the post-mining landscapes.

In order to estimate the N2-fixation potential of black locust at marginal sites leaf samples were taken from black locust trees in short rotation plantations planted between 1995 and 2007 in post-mining sites south of Cottbus (Brandenburg, NE Germany). The variation of the natural 15N abundance was measured to evaluate the biological nitrogen fixation. The nitrogen derived from the atmosphere can be calculated using a two-pool model from the quotient of the natural 15N abundances of the N2-fixing plant and the plant available soil N. Because representatively determining the plant available soil N is difficult, a non-N2-fixing reference plant growing at the same site with a similar root system and temporal N uptake pattern to the N2-fixing plant is often used. In our case we used red oak (Quercus rubra) as a reference.

The average nitrogen content in the leaves of black locust ranged from 3.1% (C/N 14.8) in 15 years old trees to 3.4% (C/N 14.4) in 3 year-old trees, respectively. A higher content of nitrogen was found in leaves of re-sprouted trees with 4.3% (C/N 11.5). The estimated percentage of nitrogen derived from the atmosphere (% NdfA) in black locust was 63% – 83% compared to 56% in seabuckthorn (Hippophaë rhamnoides) and 79% in common broom (Genista scuparia). The annual leaf biomass production of black locust varied between 1325 (2 years old trees) and 2576 kg/ha a (4 years old trees). The estimated leaf nitrogen fixed by Robinia was approx. 30.5 - 59.2 kg/ha a.

From the results, we can conclude that the biological nitrogen fixation by Robina is an important factor for the nitrogen balance of short-rotation plantations on nutrient poor-soils.