Effects of soil perforation, liming and grass seeding on soil aeration and matric potential in skidding tracks during 3 years after trafficking

Audrey Averdiek, Heinz-Christian Fründ

Site description and experimental treatments

A field experiment was set up in a beech forest in the Solling in order to explore soil perforation in combination with liming and seeding as a measure to accelerate the regeneration of soil structure. The soils are cambisols from silty Pleistocene deposits on Triassic sandstone. The site is a 34 year old beech forest from natural regeneration which received its first thinning December 2012-March 2013. During thinning skid trails were laid out with a Logset F5 harvester (6 wheels, 13 t, 2 passes), followed by a forwarder Ponsse Buffalo (8 wheels, 18 t + load, >3 passes). The site has a gentle slope inclination (Wieviel % Hangneigung?). After thinning of the stand was finished, the wheel tracks varied in track depth between 3 cm and 25 cm. The resulting soil deformation was classified into type 2, type 2/3, and type 3 in the wheel track classification of WSL (Lüscher et al. 2010). The following treatments were applied in April 2013: Soil perforation: manual punching of holes 2.6 cm diameter 20 cm depth every 20 cm or every 50 cm respectively in the wheel track. Liming: Superficial liming of the whole trail with dolomite equivalent to 12 t/ha or filling of punched holes with burnt lime equivalent to 6 t CaCO₃/ha. Seeding: Commercial shade grass mixture amended with forest herbs (25 g/m²). Every treatment was set up on a 50 m line in one skid trail with one replicate in another skid trail. Three skid trails are untreated controls. Combination of these measures led to a total of eight treatments. Altogether the experiment consists of 19 skid trails.

Measurements

The water tension in 6-10 cm soil depth was monitored with Watermark sensors. The concentration of CO₂ in 6 cm soil depth was monitored with permanently installed NIRS sensors. Iron rods in the soil (down to 27 cm) are taken as indicators for soil aeration and were exposed for six weeks in late summer every year. Additionally vegetation is monitored, and soil samples from three depths were analyzed for water content, pH, and organic carbon in 2013 und 2014.

Results

The soil air concentration of CO₂ in 6 cm depths was always below 1 % vol. in the soil outside the skidding trail. In the wheel tracks the 1 % CO₂ concentration was exceeded in more than 90% of the readings in 2013 and in 42% of the readings in 2014. In 2015 soil air CO₂ in 6 cm in the wheel tracks stayed mostly below 1 %. The CO₂-concentration was also elevated in the unpassed middle lane of the skid trails: 54 % of the readings in 2013 and in 33 % of the readings in 2014 had a CO₂ concentration above 1 % vol. There was no significant effect of the experimental treatments on the soil air CO₂ concentration. This was due to high site variability with extreme differences between replicates that received the same treatment.

Monitoring of water tension in 6-10 cm soil depth generally showed a good water supply. In summer 2013 and 2015 dry periods led to a significant increase in water tension in the soil outside the skid trails, but not in the wheel tracks and also not in the unpassed middle lane of the skid trails. It seems, as if the water extraction by tree transpiration was disconnected from the soil in the whole skid trail and tree roots were not able to exploit the uncompacted soil in the middle lane. Treatment effects on water tension in the wheel tracks were insignificant. There was a tendency towards a higher
frequency of wet conditions in the perforated soil, and in summer 2015 wheel tracks where punched holes were filled with burnt lime had the strongest water tension.

The analysis of the iron rods confirmed the results of the CO₂ monitoring. The percentage of rod surface indicating anoxic conditions increased with soil depth down to the depth range 9-12 cm. From 12 to 24 cm depth this percentage remained rather constant. As with CO₂ and water tension the difference between iron rods from different treatments was not convincing.

Examination of selected perforation holes showed that organic matter had been accumulating in the holes. Furthermore the holes were colonized by roots and earthworms. Holes filled with burnt lime were rather unchanged after three years.

Conclusion

CO₂ measurement, monitoring of water tension, and redox indication with iron rods showed that driving with harvester and forwarder not only affected the wheel tracks but also the unpassed middle lane of the skidding trails. The decrease of CO₂-concentration in the soil air indicates an initial regeneration of air diffusivity in the first 6 cm of the impacted soil within the first three years after trafficking, which is most likely attributable to abiotic weathering. An accelerating effect of soil perforation, liming and grass seeding was not observed. Further observation is necessary, to see, if the onset of biological regeneration is favored by the measures taken.

Reference