Variability of Soil Fertility and Crop Yield on a Sandy Field Site in Western Poland under Bio-dynamic Management

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Introduction

In the highly variable landscape of western Poland that has developed after the last glaciation about 10000 yrs. ago heavy clay soils, peat, and light sandy soils are abundant and often occur close to each other. Sandy sites are often the most troublesome to manage as they have a low water holding capacity and low pH. The role of organic matter in these soils is highly important to enhance soil fertility. In the study area soils were managed according to bio-dynamic principles since 1995. However, soil fertility is still not satisfying because of the limited amount of manure available. Without irrigation crop yields are low, due to low rainfall between March and June and low water holding capacity of soils (mean annual precipitation 750 mm, mean annual temperature 8.5°C). The aim of our research project on the Juchowo farm was to enhance soil fertility and stability by implementing reduced soil tillage in combination with mineral supplements as additional fertilizers to the regular manure application. The selected field for our research project has been tested for homogeneity of soil analyses and crop yield, the results of which are presented here.

Material and methods

A field site on the Juchowo farm has been selected for analysing the spatial variability of soil fertility and crop yield. On a selected area of approx. 3 ha, 40 plots of 12 × 50 m size were defined and soil samples were taken in May 2010 as a bulk sample from 20 soil cores down to 70 cm depth. In each of the soil layers sampled (0-10, 10-30, 30-50, 50-70 cm) pH (0.1M KCl), soil texture, soil carbon and total nitrogen (Nelson and Sommers, 1996) and plant available nutrients (Egnér et al., 1960) were determined. Soil microbial biomass carbon (C_{mic}) and nitrogen (N_{mic}) (Brookes et al., 1985; Vance et al., 1987) and soil basal respiration (Isermeyer, 1952) was determined in the two top layers only (0-10 and 20-30 cm). Winter rye was cultivated in 2010 and was harvested plot-wise with a farm-owned harvester. All data were subject to statistical testing using a combined model (JMP 8.0, 2008).

Results

The soils of the field averaged at 91.4% sand, 6.3% silt and 2.3% clay and had a bulk density that was slightly increasing with depth from 1.48 to 1.57 g cm^{-3}. In the selected field, two zones were identified with clearly different winter rye grain yield (14% moisture). Overall the yield was very low. Along a slight slope grain yields were 0.78 (± 0.09) t ha^{-1}, whereas they were 1.2 (± 0.12) t ha^{-1} on a plain area. Soil organic C in the top soil was 6.3 (± 1.4) mg g^{-1} and decreased to 3 (± 1.4) mg g^{-1} in the lowest soil layer. The trend for total N was similar. In the zone with high crop yield, soil carbon stocks over 0-70 cm depth averaged at 31 (± 5.7) t ha^{-1}, whereas in the zone with low crop yield they were 23 (± 3.5) t ha^{-1}. Nevertheless, the regression of crop yield with carbon stocks was low with r^2=0.2. C_{mic} in the top 30 cm of the high yield area were 441 (± 65) kg ha^{-1} and in the low yield area they were 341 (± 57) kg ha^{-1} and correlated with an r^2=0.48 to rye yield. The same r^2 was found for N_{mic} showing 67 (± 10) kg ha^{-1} in the high yield area and 52 (± 5) kg ha^{-1} in the low yield area.

Soil pH averaged at 6.2 in the top layer (0-10 cm) and increased to 6.6 at 50-70 cm depth. pH was negatively correlated to soil organic carbon indicating either a pH effect on carbon stabilization or carbon inputs decreased soil pH. Phosphorus and potassium-levels also showed some spatial effects but were poorly related to crop yield.

This assessment of spatial variability served to design a balanced layout of a field trial. The effect of four reduced tillage options (cultivator and skim plough with or without loosening at 30 cm) as compared to ploughing at 30 cm depth is currently tested with regard to the development of soil fertility parameters and crop yield. Farm owned machinery is used for all field operations.

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Discussion

Soil organic matter is an important factor to explain crop productivity at this site due its multiple functions in physical, chemical and biological characteristics of soil fertility. The role of soil microbial biomass as a biological indicator of soil fertility and as a source and mediator of plant nutrients has been approved (Jannoura et al., 2013). The multifactorial role of soil organic matter in supporting soil fertility and crop growth appears to be of particular importance in sandy soils.

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