Long-term changes in soil nutrients and grass/clover yields on Tingvoll farm

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Implications

Long term studies (1989-2012) of soil nutrients and ley yields on a Norwegian organic dairy farm (Tingvoll experimental farm) showed that soil nutrient concentrations decreased over time after conversion. A potential decline in yields due to reduced nutrient concentrations will be difficult to detect, because of large annual variations in yield levels. The sustainability of the nutrient management on the farm should be considered, aiming at keeping soil nutrient concentrations above levels impacting negatively on the yields.

Background and objectives

Organic milk production was established at Tingvoll farm during 1989-1994. The nutrient supply has been manure from the herd, biological nitrogen (N) fixation and some application of lime. The farmers aim at utilizing local resources in a sustainable way. Over the years, milk production has increased due to renting of land and milk quota. A new loose housing barn in 2011 increased the tenant cost. Likewise to most other Norwegian dairy farmers, the tenants at Tingvoll farm have replaced local resources (grazing) by purchased inputs (concentrates) to increase the economic output.

Since1991, yield levels have been recorded annually on most cultivated fields belonging to Tingvoll farm. All cultivated soils (0-20 cm depth) were analyzed for concentrations of phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca) and pH (H_2O) in 1989, 1995, 2002 and 2009. K was analyzed by K-HNO_3 and AL-extraction; other nutrients only by AL-extraction. Former studies of organic dairy farms aiming at self-sufficiency with nutrients (Løes and Øgaard 1997) showed that soil P and K concentrations decreased with time when the import of P was moderate to low (P surplus below 50 kg ha^{-1} yr^{-1}). For K, no correlation was found between K budgets and changes in soil K. In this paper, yield levels are discussed in light of changes in soil nutrient concentrations.

Key results and discussion

The average N, P and K budgets for Tingvoll farm in the period 1994 to 2009 measured in kg nutrient ha^{-1} yr^{-1}, were -0.9 (±5.7) for N, 1.1 (±2.1) for P and 2.1 (±2.7) for K. Nitrogen fixation is not included in these values. On average for all topsoil samples from cultivated soils (n=18), the average P-AL concentrations decreased from 21 to 13 mg 100 g^{-1} dry soil (Fig. 1), Mg-AL from 9 to 6, and K-HNO_3 (n=8) from 175 to 135. For K-AL, values varied between 8 and 11 (Fig. 1), and for pH between 5.9 and 6.1. This corresponds well to the study referred above. The average nutrient concentrations in 2009 are considered as high for P-AL (optimum value 5-7 mg 100 g^{-1} dry soil), as well as for Mg-AL and K-HNO_3. For K-AL, they are considered as medium high.

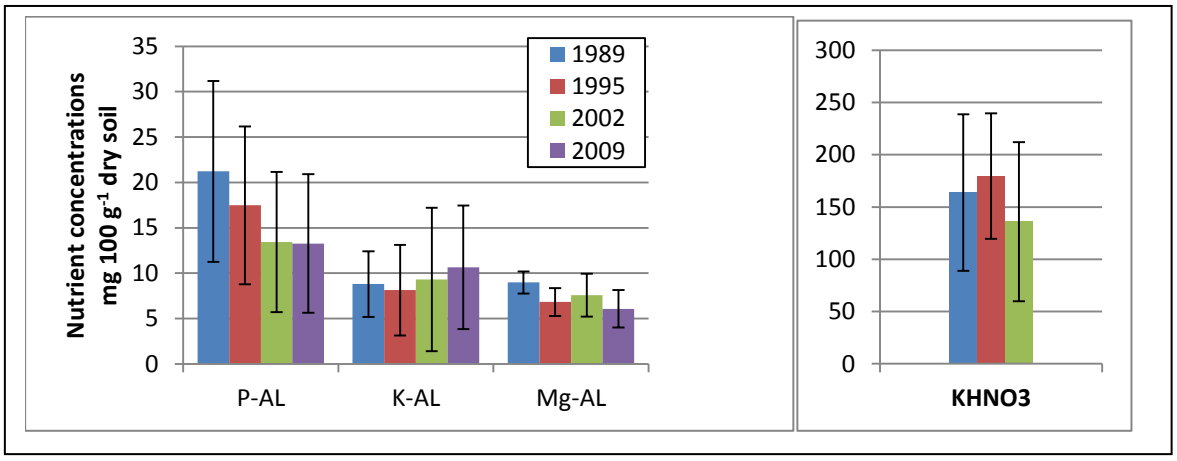

Figure 1. Average nutrient concentrations and standard deviations in the topsoil (0-20 cm) over time.

The grass yields have fluctuated during the period (Fig. 2). Since 2012, all forage has been harvested as round bales. This has reduced the duration of the harvest period significantly, and hence the dry matter (DM) yields have declined. Ley yields are influenced by weather conditions (Fig. 2). In 1994 and 2010, yields were low due to low temperature and high precipitation during May and June. In 1992, 2002 and 2011, yields seemed to be restricted by drought, because May + June had high temperature and low precipitation. High levels were achieved in 1997 and 2001, with low precipitation and moderate temperature, as well as in 2004-07 + 2009 with variable climatic conditions. Nutrient mineralization in the soil and biological nitrogen fixation increases by favorable temperature and moisture conditions. The long-term trend of ley yields is slightly negative. Weather does of course not explain all yield variations. It cannot be excluded that reduced soil nutrient concentrations over time may contribute to this trend.

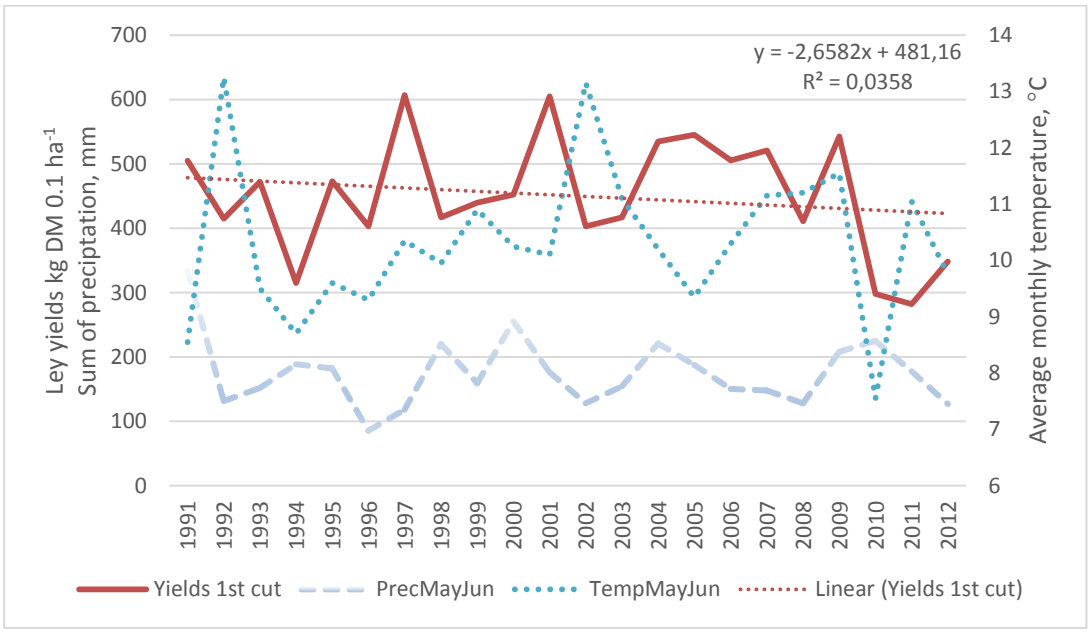

Figure 2. Average ley yields from first cut 1991-2012, x-y fields per year, compared with climatic conditions in May and June measured in Tingvoll.

How work was carried out?

Nutrient budgets were calculated based on farm accounts and standard values of N, P and K concentrations (Løes et al. 1996), adjusted for storage of concentrates at the turn of each year except for the period 2004-09. Gross yields where determined by harvesting 5 representative plots of 10 m^2 on each field. Dry matter (DM) content was determined. Soil samples (0-20 cm soil depth) were taken from all cultivated fields, as composites of 10-12 soil cores taken within 5 m distance from a sample point described on a map to ensure that the sample points were the same in each sampling year. Ammonium acetate-lactate extraction (AL) is the routine analysis for measuring soil nutrient concentrations in Norway.

References

Løes, A.-K., Fritsvold, B., Schmidt, K. 1996. Omlegging til økologisk landbruk. Landbruksforlaget, Oslo, 318 p.

Løes AK and Øgaard A. 1997. Changes in the nutrient content of agricultural soil on conversion to organic farming, in relation to farm level nutrient balances and soil contents of clay and organic matter. Acta Agric. Scand. Sect. B, Soil Plant Sci 47, 201-214.