



Tile drain losses of nitrogen and phosphorus from fields under integrated and organic crop rotations. A four-year study on a clay soil in southwest Sweden

Maria Stenberg ^{a,b,*}, Barbro Ulén ^c, Mats Söderström ^a, Björn Roland ^b, Karl Delin ^d, Carl-Anders Helander ^b

^a Swedish University of Agricultural Sciences, Department of Soil and Environment, PO Box 234, SE-532 23 Skara, Sweden

^b Rural Economy and Agricultural Society of Skaraborg, PO Box 124, SE-532 22 Skara, Sweden

^c Swedish University of Agricultural Sciences, Department of Soil and Environment, PO Box 7014, SE-750 07 Uppsala, Sweden

^d Varaslättns Lagerhus, Lagerhusgatan 4, SE-534 31 Vara, Sweden

ARTICLE INFO

Article history:

Received 15 April 2011

Received in revised form 9 December 2011

Accepted 14 December 2011

Available online 20 January 2012

Keywords:

Cropping system

Degree of phosphorus saturation

Leaching

Soil mineral nitrogen

Nitrogen fixation

Water nutrient balance

ABSTRACT

In order to explore the influence of site-specific soil properties on nitrogen (N) and phosphorus (P) losses between individual fields and crop sequences, 16 drained fields with clay soils were investigated in a four-year study. Mean total N (TN) loss was 6.6–11.1 from a conventional, 14.3–21.5 from an organic and 13.1–23.9 kg ha⁻¹ year⁻¹ from an integrated cropping system across a 4 year period, with 75% in nitrate form (NO₃-N). Mean total P (TP) loss was 0.96–3.03, 0.99–4.63 and 0.76–2.67 kg ha⁻¹ year⁻¹, from the three systems respectively during the same period, with 25% in dissolved reactive form (DRP). Median N efficiency was calculated to be 70% including gains from estimated N fixation. According to principal component factor (PCA) analysis, field characteristics and cropping system were generally more important for losses of N and P than year. Accumulation of soil mineral N in the autumn and (estimated) N fixation was important for N leaching. No P fertilisers were used at the site in either cropping system. Total P concentration in drainage water from each of the fields was marginally significantly ($p < 0.05$) correlated to TP concentration in the topsoil ($r = 0.52$), measured in hydrochloric acid extract (P-HCl). Mean DRP concentrations were significantly ($p < 0.01$) correlated to degree of P saturation (DPS-AL) and soil carbon (C) content in the topsoil ($r = 0.63$). Good establishment of a crop with efficient nutrient uptake and good soil structure was general preconditions for low nutrient leaching. Incorporation of ley by tillage operations in the summer before autumn crop establishment and repeated operations in autumn as well, increased N leaching. Crop management in sequences with leguminous crops needs to be considered carefully when designing cropping systems high efficiency in N utilisation and low environmental impact.

© 2011 Elsevier B.V. All rights reserved.

1. Introduction

Efficient use of added nitrogen (N) and phosphorus (P) is highly important in all arable farming systems, as transport of N and P in runoff and drainage from agricultural soils causes pollution and eutrophication of surface waters (e.g. Carpenter et al., 1998; Sims et al., 1998). These two nutrients act in concert in the aquatic system and concentrations of both need to be reduced in order to prevent harmful algae and cyanophycea blooms (Smith, 1983; Boesch et al., 2006). However, some nutrient transport by water occurs even under balanced systems (e.g. Öborn et al., 2003; Ulén et al., 2005). Nordic agricultural areas with clay soils are mostly systematically drained and knowledge about nutrient leaching mainly derives from drained experimental plots with specific management measures. In contrast, there is little knowledge about nutrient transport from

arable fields with different types of crop sequences and on farm scale in actual crop production.

Conventional crop production on farms without livestock requires import of N and P in mineral fertiliser, and weeds and pests are managed by pesticides. Tillage operations for incorporation of crop residues, management of weeds and soil loosening are commonly carried out by mouldboard ploughing of the topsoil, while primary tillage and seedbed preparation are carried out using tine cultivators. Integrated crop production (Vereijken, 1997; Helander and Delin, 2004) is a form of production with reduced inputs of fertilisers and pesticides and with less intensive tillage. Reduced tillage generally consists of tine cultivation of the upper topsoil or direct drilling instead of regular inversion of the whole topsoil. Such measures influence soil physics (Rasmussen, 1999; Bolan et al., 2005), as well as N and P leaching losses (Ulén et al., 2010). Somewhat lower yields but similar profits (based on lower energy costs) act in favour of integrated farming (Holland, 2004).

Organic crop rotations in Sweden are usually certified by Swedish KRAV® (<http://www.krav.se>) or subsidised. Mineral fertilisers or pesticides are not used, and only certified organic fertilisers are

* Corresponding author at: Swedish University of Agricultural Sciences, Department of Soil and Environment, PO Box 234, SE-532 23 Skara, Sweden. Tel.: +46 511 67274, +46 70 2997274 (mobile); fax: +46 511 67134.

E-mail address: Maria.Stenberg@slu.se (M. Stenberg).

permitted (Rodrigues et al., 2006). The associated limited nutrient supply, as well as weeds and pests, may limit organic crop yield (Watson et al., 2002). Crop N requirements may be met by leguminous crops such as clover species (*Trifolium* spp.) in green manure (GrM) leys or harvested crops such as peas (*Pisum sativum* L.) or faba bean (*Vicia faba* L.). On farms without live-stock, GrM can supply P to the topsoil by root uptake and release when incorporated, together with slow-acting bonemeal and other P amendments allowed in organic farming. Frequent use of GrM may enhance risk for N leaching by inappropriate timing of N release from the GrM and N uptake by crops (e.g. Korsæth et al., 2002; Askegaard et al., 2005). Catch crops or cover crops (e.g. Berntsen et al., 2006) are often used in crop rotations in all kinds of production systems to minimise N losses to the environment during late autumn and winter periods without a main crop, when the risk of mineral soil N leaching is great (Haynes, 1996).

Phosphorus transport down through the soil and via drain tile systems to the surface waters are important in many parts of the Nordic region, which is characterised by moderate rainfall, relatively flat topography and tile-drained, fine-textured soils (Heckrath et al., 2008). High concentrations of dissolved reactive P (DRP) and P bound to colloidal clay particle have been observed in tile drain water from soils with a high content of the most common clay mineral, illite (Ulén, 2003; Ulén and Snäll, 2007). A particular concern with stockless organic farming is increased P leaching, which may derive from P-rich organic green manure (Ulén et al., 2005; Torstensson et al., 2006). Dissolved reactive P has been reported to leach from the extremely green grass in buffer strips of such vegetation (Uusi-Kämpä, 2005). Another concern in organic farming is frequent incorporation of leys, generating

a risk of high losses in the form of colloidal P from clayey soil (e.g. Bilotta et al., 2007).

The overall objective of the present study was to analyse variations in N and P losses via tile drains between fields within a number of crop sequences representing organic, integrated and conventional production on an experimental farm. The design of the organic and integrated cropping systems was intended to improve soil structure and crop yields by increasing the amount of perennial crops in the rotations and reducing soil tillage. Specific hypotheses were that tile drain N and P losses are influenced by: 1) Site-specific soil properties in individual fields, and 2) crop sequence and production system.

2. Materials and methods

2.1. Experimental site and cropping system

An existing full-scale experiment at the Logården research farm (60 ha) in south-west Sweden (58°20'N, 12°38'E, altitude 50 masl) was used for studies of tile drain losses of N and P (Fig. 1A–B). Mean annual precipitation at the site is 604 mm and mean annual air temperature 6.3 °C as a 30-year average for 1961–1990 at a nearby meteorological station (Sätenäs 58°26'N, 12°42'E) (Alexandersson and Eggertsson Karlström, 2001).

The tile drain system on the whole farm was renovated in 2003. An 8 m spacing was chosen to provide efficient infiltration on this dense soil and a total of 16 fields (3–4 ha each) were separately drained. Approximately a 0.1 m layer of gravel (8–16 mm in diameter) was used as a permeable backfill over the drains. Twelve years previously, in 1991, the farm had been divided into three farming systems: conventional

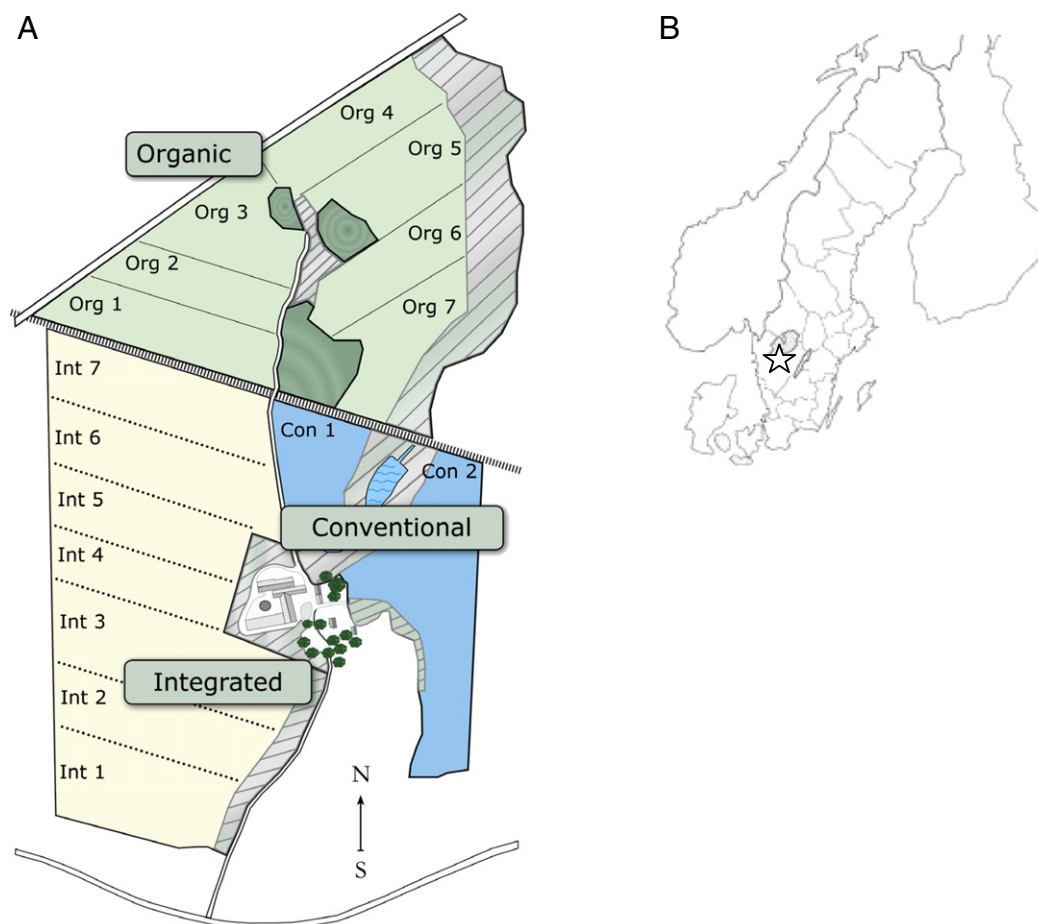


Fig. 1. (A) The fields at the Logården experimental farm situated close to Grästorps (B) in southwest Sweden.

Download English Version:

<https://daneshyari.com/en/article/4429308>

Download Persian Version:

<https://daneshyari.com/article/4429308>

[Daneshyari.com](https://daneshyari.com)