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Simulating Phosphorus Leaching from Fields with Different Farming Practices

Introduction

Phosphorus (P) leaching from arable land is the main cause of eutrophication in rivers, lakes, and coastal waters. The range of different conditions for cultivation together with the variety of farming practices makes it difficult to estimate the phosphorus load from agriculture by field measurements only. With the help of modeling it is possible to estimate the current phosphorus load, as well as to predict the development of the load in changing climate conditions. In addition, modeling may be a practical tool for estimating the effect of different farming practices on P load.

The goal of this work is to develop ICECREAM model so that it could be used for predicting P load from a variety of agricultural practices and field conditions. Modified ICECREAM model is used for simulating three different fields with diverse farming practices. The simulated P load is compared to measured data. The ICECREAM model is coupled with WSFS-VEMALA which simulates hydrology and water quality for all river basins in Finland (Huttunen et al. 2008). Coupled modeling system is applied to all the ca 1,100,000 field plots of the country. The results from Aurajoki river basin (Figure 5) are shown as an example of this model combination.

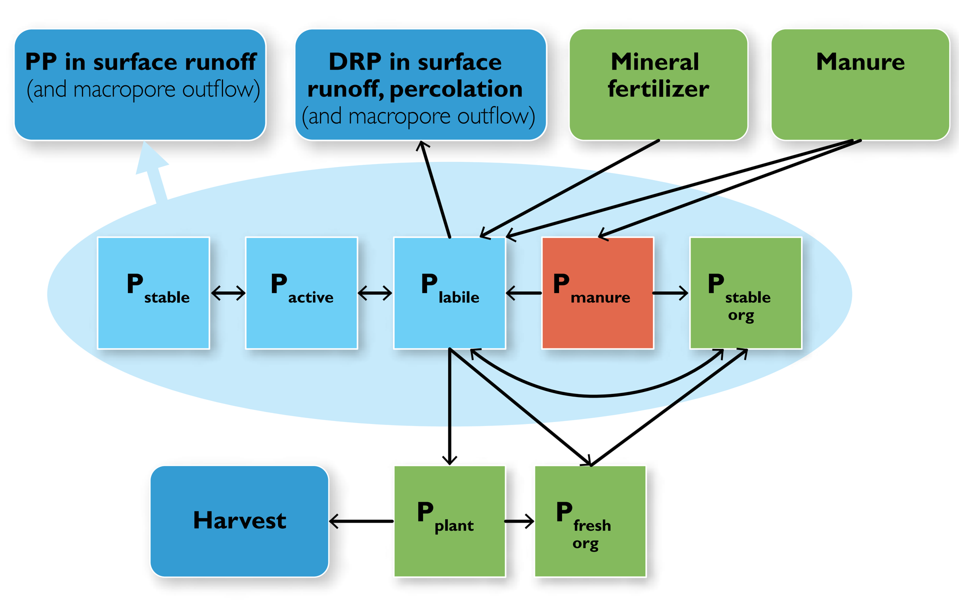

Fig 1. Phosphorus submodel in the ICECREAM model

Methods

ICECREAM is a field scale model which is based on CREAMS and GLEAMS models, applied for Finnish conditions by Rekolainen and Posch (1993), and further developed by Tattari et al. (2001), Yli-Halla et al. (2005) and Bärlund et al. (2009). In this work some modifications to the model were made to better simulate the effects of changes in agricultural practices, for example cultivation of different crops, leaving stubble over winter, and different levels and depths of fertilization. The main changes include

- introduction of macropores in the fine textured soils according to Jaakkola et al. (2012)
- revisions to the initialization of phosphorus pools
- change in the balance calculations between the P pools
- a new method for calculating phosphorus concentration in surface runoff
- modifications to the hydrological part of the model
- introduction of a subroutine for calculating phosphorus leaching from surface applied manure according to Vadas et al. (2007)

The phosphorus pools and P exchange between them are shown in Figure 1.

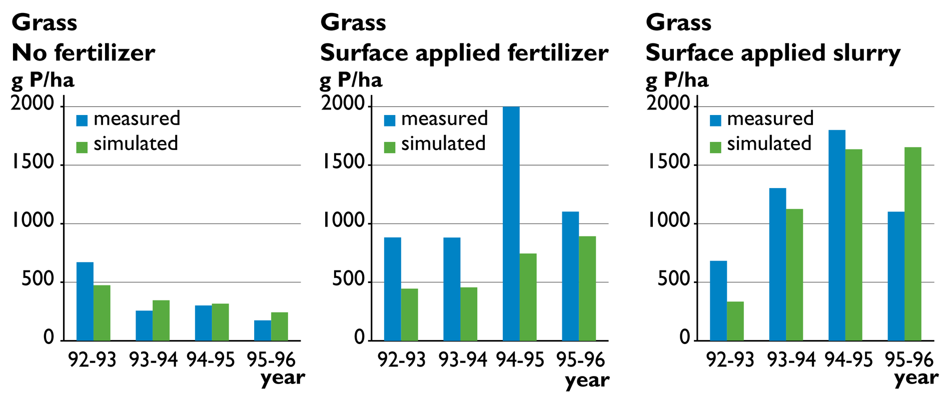

Fig 2. Total phosphorus load from the Toholampi field with different farming practices
Field characteristics:
- 5 % clay, 92 % silt, 3 % sand
- 0,5 % slope
- Soil test P: 6,5

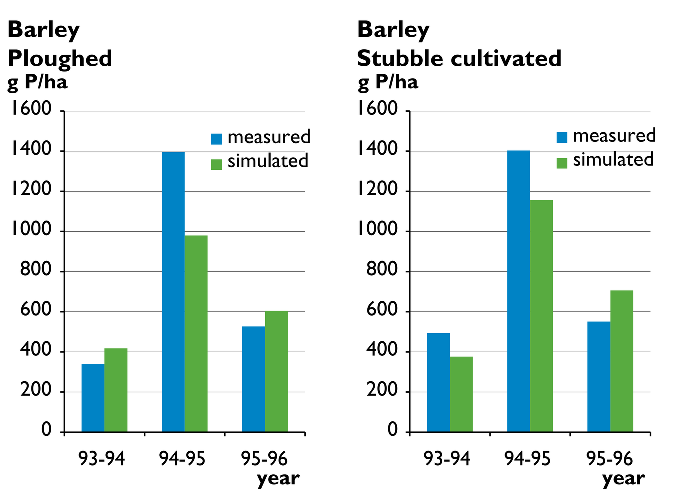

Fig 3. Total phosphorus load from the Kotkanoja field (Jokioinen) with different farming practices.
Field characteristics:
- 61 % clay
- 2 % slope
- Soil test P: 4

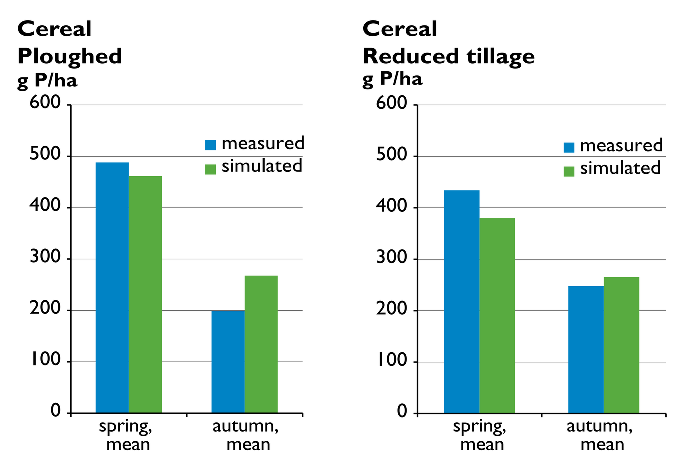

Fig 4. Total phosphorus load from the Kotkaniemi field (Vihti) with different farming practices.
Field characteristics:
- 38 % clay
- 3,7-5,7 % slope
- Soil test P, ploughed: 6,5
- Soil test P, non-ploughed: 10

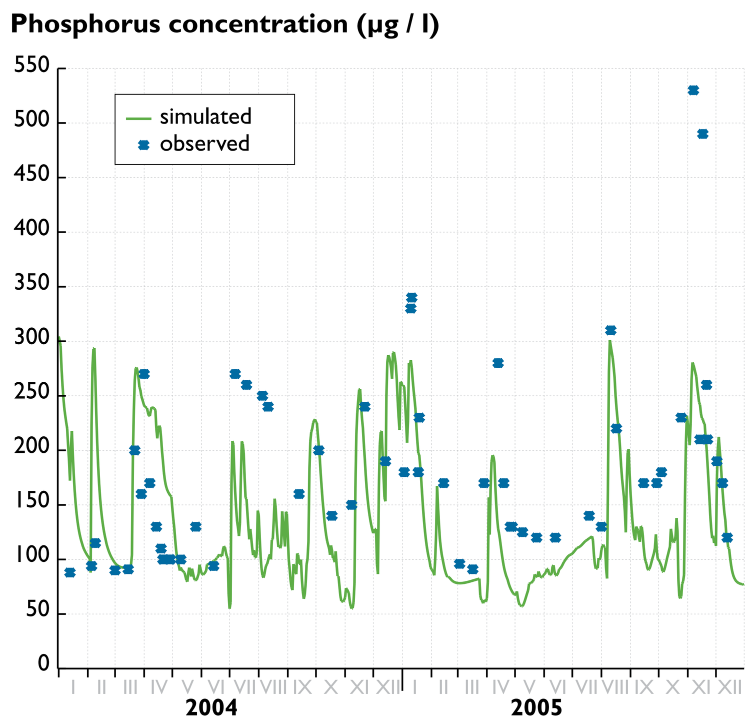

Fig 5. Phosphorus concentration (µg/l) in river Aurajoki during 2004–2005.

Results

The modified version of ICECREAM still needs to be improved to take account of greater increase in P load when fertilizer is applied on the soil surface (Figure 2). The P load from non-fertilized grass is simulated adequately. The model is able to simulate the difference between traditional tillage and stubble cultivation (Figure 3) giving somewhat higher P loads from stubble cultivation. From reduced tillage the model gives slightly lower P loads than from traditional tillage (Figure 4). However, the measured P load is the same for both tillage methods. The model results are similar to the measured ones but the increase in dissolved P load of reduced tillage compared to traditional tillage is not big enough.

Conclusions

The similarity of the model results to the measured ones shows that ICECREAM model can be used for estimating the phosphorus load from arable land in Finland. The influence of different tillage methods to the P load still needs to be further evaluated by experts. Because of the detailed process descriptions the model can be presumed to give fairly accurate results also in climate change scenarios.

Acknowledgement

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