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A model analysis on nitrate leaching under different soil and climate conditions and use of catch crops

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The use of crops and catch crops with deep rooting can strongly improve the possibility of retaining nitrate-N that will otherwise be leached to the deeper soil layers and end up in the surrounding environment. But will it always be an advantage for the farmer to grow a catch crop? This will depend on factors such as soil mineral nitrogen level, soil water holding capacity, winter precipitation, rooting depth and N demand of the succeeding crop. These factors interact, and it can be very difficult for farmers or advisors to use this information to decide whether growing a catch crop will be beneficial. To analyse the effect of catch crops under different Danish soil and precipitation conditions (Figure 1), we used the soil, plant and atmosphere model Daisy.

All simulations:

- Weather data is an average for 1961 - 1990
- Started on the 1st of August and ended 1st of June the following year

Split levels in simulations:

- Precipitation:
  - Low: 660 mm y^{-1} (110 mm winter surplus)
  - High: 990 mm y^{-1} (440 mm winter surplus)
- Soil type:
  - Sand
    - 4% clay
    - Mineral-N 135 kg (0-2.0 m)
  - Sandy loam
    - 12.5 % clay
    - Mineral-N 150 kg (0-2.0 m)
- Crops:
  - No Catch crops
  - Ryegrass (rooting 1 m)
  - Oil radish (rooting 2 m)

Bare soil simulations were prepared to show the effects of soil texture and precipitation. Table 1 shows simulations of nitrate leaching in two depths with the different combinations of soil texture and precipitation regimes.

Table 1. Nitrate leaching below two different depths 1st of June in simulations with no use of catch crops. Simulation example with high residual N in autumn.

Precipitation	Soil type	[kg N ha^{-1}] 1.0 m	[kg N ha^{-1}] 2.0 m
Low	Sand	131	75
High	Sand	174	168
Low	Sandy loam	113	23
High	Sandy loam	164	113

Use of catch crops can significant reduce nitrate leaching in a situation with high residual nitrogen in autumn. Table 2 shows the effect of two catch crops, commonly grown in Denmark, with different rooting depth, soil types and precipitation levels.

Oil radish reduces nitrate leaching better than ryegrass due to deeper rooting depth and higher N uptake. Under conditions with low residual N, and low nitrate concentrations in deeper layers, ryegrass will have nearly same effect as oil radish (Data not shown).

Table 2. Reduction in nitrate leaching by two catch crops.

Precipitation	Soil type	Catch crop	Soil 1.0 m	Depth 2.0 m
Low	Sand	Ryegrass	55 %	55 %
Low	Sand	Oil radish	95 %	90 %
High	Sand	Ryegrass	65 %	65 %
High	Sand	Oil radish	90 %	90 %
Low	Sandy clay loam	Ryegrass	60 %	40 %
Low	Sandy clay loam	Oil radish	95 %	85 %
High	Sandy clay loam	Ryegrass	65%	55 %
High	Sandy clay loam	Oil radish	90 %	95 %

Annual precipitation and soil types in Denmark

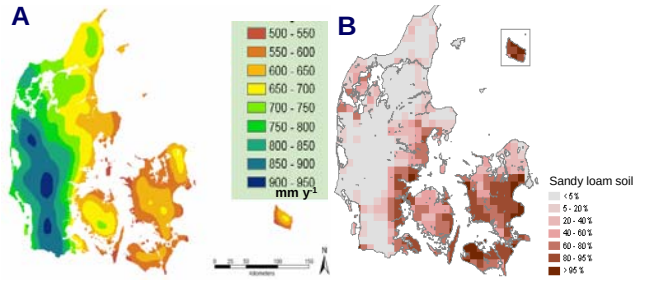

Figure 1. A: Average precipitation in Denmark from 1961 to 1990. **B.** Illustration of soil texture in Denmark, here split up in sandy soils (grey) and sandy loam soils (dark red). (Maps from www.DJFgeodata.dk).

Figure 2 shows a simulation of mineral N in the soil profile. Mineralisation from catch crop residues increases mineral N in top soil. Oil radish was best to take up N in the whole soil profile. In the sandy soil and sandy loam part of nitrate was leached further down before roots had developed into those soil layers. At the low precipitation and sandy soil the N front had reached 1.25 m depth, a deep rooted main crop the following year will be able to take up this N, and the use of a catch crop is not necessary.

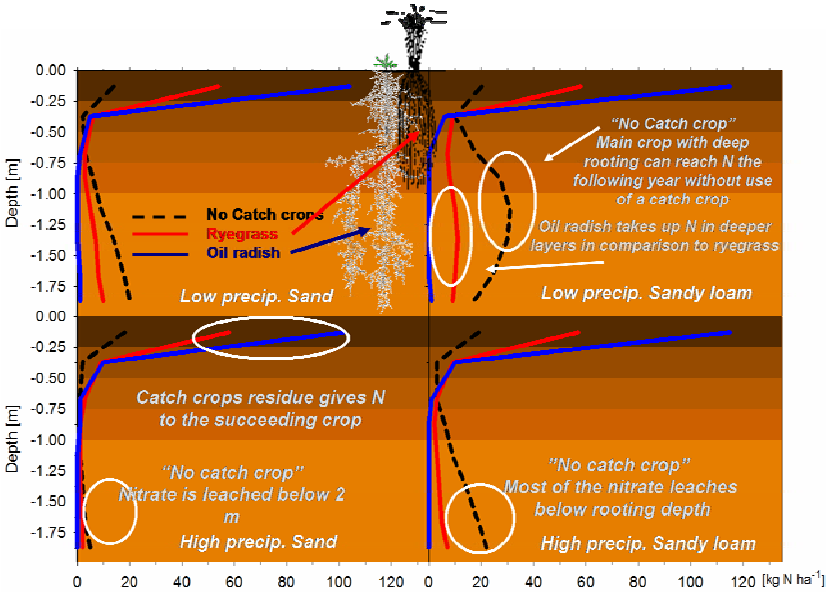

Figure 2. Mineral nitrogen 1st of June in soil profile from simulation examples. Left: Sandy soils, Right: Sandy loam soils, upper part: Low and below: High precipitation.

Conclusions

-Model work can help calculate how deep the nitrate leaching front is located, to decide the catch crop strategy

-In a sandy soil it will often be an advantage to grow catch crops

-Oil radish with deep roots retain mineral N better than ryegrass with shallow roots

-In a sandy loam soil and low precipitation catch crops can have negative effect on the availability of nitrate the following spring

-It is important to know location of high nitrate concentrations in soil profile to chose the right catch crop strategy

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