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Optimizing N-Transfer in Winter Wheat Cropping Systems through Microbial N-Immobilization

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Introduction & Aims

Nitrate surplus after harvest is a serious issue regarding groundwater pollution and GHG emission. Several studies showed the impact of tillage intensity and crop residue composition on N-turnover (Henke et al. 2008, Abiven et al. 2005). However, there is a lack of information about stimulation of microbial immobilization with regard to its total amount and timing.

In order to assess residue management as an option to prevent N-losses we try to enlighten the post-harvest N-dynamics and strive to simulate mineralization, leaching and N-uptake during the whole growth period.

Fig. 1: 24 blocks (red boxes) on the experimental site Hohenschulen near Kiel, Germany; in total 528 plots on 2.4 ha; source: K. Sieling, 2016

Methods

Two crop rotations were established in a split plot design field trial (Fig. 1). The soil microbial activity is manipulated in field scale by post-harvest application of organic substrates (Fig. 2 & 3).

Data collected for model calibration include soil mineral nitrogen contents, atmospheric conditions, as well as soil moisture and temperature. Also trace gas emissions have been measured. During the growth period 2016 N-uptake dynamics are observed via spectral measurements and recording of the leaf area index.

Fig. 2: Wheat block consisting of 22 plots after substrate application; clockwise from upper left: sawdust, no substrate, wheat straw, WOSR straw; source: S. Rothardt, 2015

Preliminary Results

First data obtained in autumn and winter 2015/16 suggest different turnover rates depending on the substrate treatment. Wheat straw incorporation shows the strongest reduction of N_2O-emission rates and soil mineral N retention, which is presumably due to immobilization.

Outlook

N-immobilization processes can be described as an indirect effect of organic C metabolism, where the nitrogen flow is mainly ruled by the C/N ratio of the organic biomass incorporated as well as by soil moisture and temperature regime. Therefore a four carbon pool based model in HUME modelling environment (Kage & Stützel, 1999) will be refined.

Batch experiments by project partners with respect to root-soil-interaction, uptake rates and the microbial community are in progress and may also be used for model calibration and extrapolation of further substrate treatments.

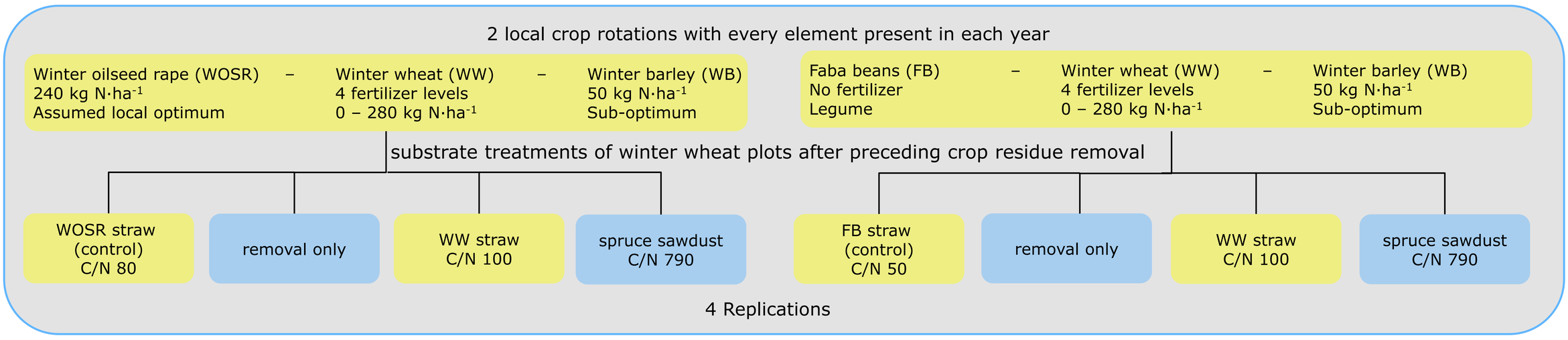

Fig. 3: Scheme of the field experiment setup

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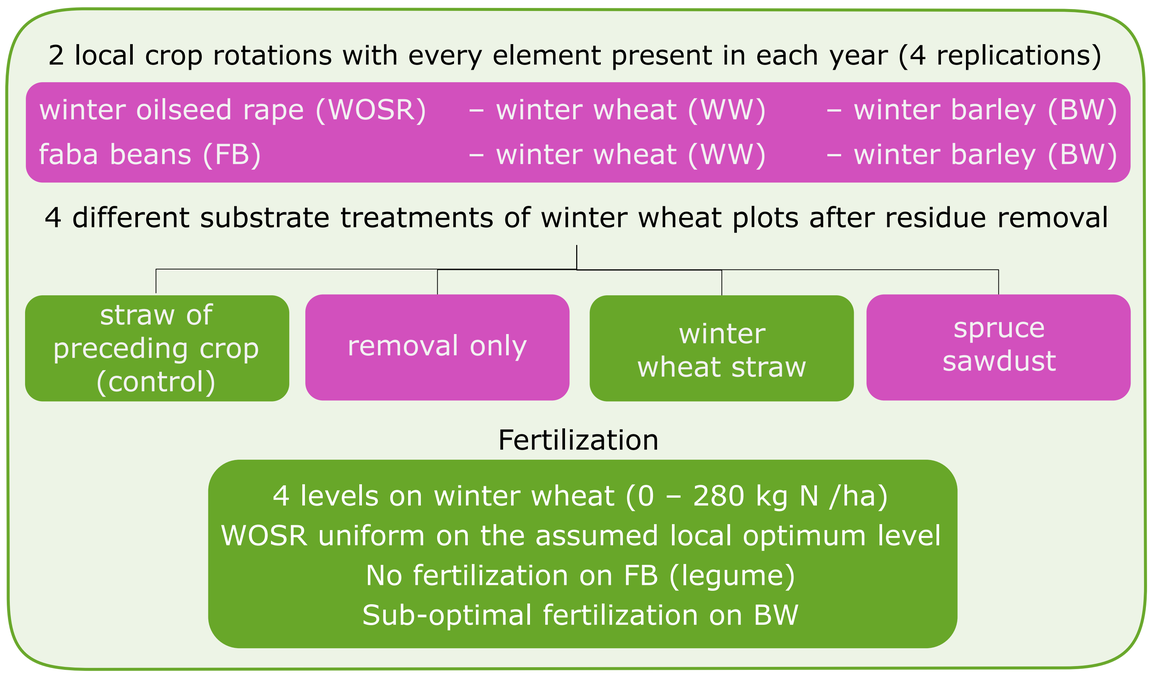
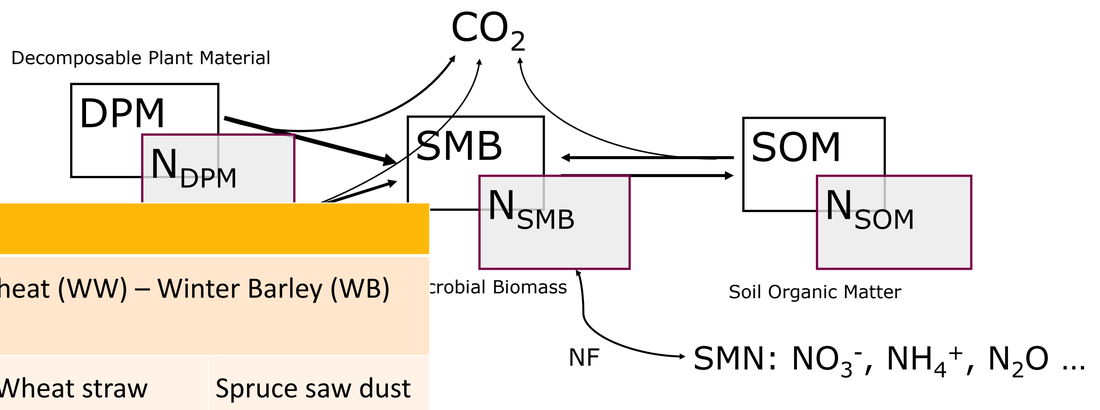


Fig. 3: Scheme of the field experiment setup and factors

- 4 replications of 2 local crop rotations with every element present in each year:
  winter oilseed rape (WOSR) – winter wheat (WW) – winter barley (BW)
  faba beans (FB) – winter wheat (WW) – winter barley (BW)
- 4 different post-harvest substrate treatments of winter wheat plots after residue removal:
  straw of preceding crop (control), removal only, winter wheat straw, spruce sawdust
- 4 fertilizer levels on winter wheat, uniform fertilization of preceding and following crops on the assumed local optimum level

Further factors of the experimental setup are:

- 2 crop rotations with every element present in each year (4 replications)
  - WOSR – winter wheat (WW) – winter barley (WB)
  - Faba beans (FB) – WW – WB
- Fertilization
  - 4 levels on winter wheat (0 – 280 kg $N \cdot ha^{-1}$)
  - WOSR uniform on the assumed local optimum level (240 kg $N \cdot ha^{-1}$)
  - No fertilization on FB (legume)
  - Sub-optimal fertilization on WB (50 kg $N \cdot ha^{-1}$)



oach. Source: Böttcher 2013, referring to Jenkinson & Petersen et al. 2005

Tab. 1: Factors of the experimental setup

Factor	Levels			
Crop rotation	Winter Oil Seed Rape (WOSR) – Winter Wheat (WW) – Winter Barley (WB) Faba Beans (FB)) – WW – WB			
Substrate treatment	Straw of preceding crop	Residue removal – no substrate	Wheat straw	Spruce saw dust
Fertilization	4 levels on winter wheat (0 – 280 kg $N \cdot ha^{-1}$)	WOSR uniform on the assumed local optimum level (240 kg $N \cdot ha^{-1}$)	Sub-optimal on WB (50 kg $N \cdot ha^{-1}$)	No fertilization on FB (legume)