STØTTET AF

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SATELLITES REVEAL NITROGEN LOSS

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By using new satellite technology, this project aims to reveal the amount of nitrogen uptake by catch crops and, thereby, enable a more precise prediction of the nitrogen need for the following crop. The method will be implemented in Denmark through a unique fertilizer planning platform used by almost all Danish farmers. Catch crops retain nitrogen during autumn and winter and release it for the following crop. Therefore, the total need of the following crop will be dependent on the amount of retained nitrogen. For this reason and, since catch crops are a substantial part of the Danish regulation, nitrogen leaching in Denmark could be significantly reduced by predicting the nitrogen uptake in catch crops. In 2018, the claim for mandatory catch crops was about 15 percent of the total agricultural area and will be 25 percent in 2021. Firstly, the most suitable spectral bands for measuring nitrogen uptake in catch crops will be found. Secondly, the project aims to establish a relationship between the satellite measurements and the amount of nitrogen in catch crops. The method includes selecting 40 fields each year, where nitrogen uptake is measured in the plant material. Satellite data from the same fields enable establishment of a relation between the satellite index and nitrogen uptake. As a supplement, soil samples will be taken in the same fields in the following spring, which will measure N-min (mineral nitrogen). Preliminary results with only 13 data points show a positive relationship between normalized difference vegetation index (NDVI) of catch crops in the autumn 2017 and the nitrate content (25-50 cm) in February 2018 (R^2 = 0.40). Most of the catch crops in Denmark are fodder radish which is destroyed by ploughing or by frost. The hypothesis is that, higher NDVI reflects higher nitrogen uptake, and more nitrogen is available as nitrate in February. Measurements were also done in oilseed rape fields, and with only 13 data points a negative relationship was found between NDVI in autumn and N-min (0-100 cm) in February (R^2 =0.52). This may reflect that high nitrogen uptakes will reduce nitrogen content in the soil, since oilseed rape is not destroyed by frost. Autumn 2018 is the first year to measure nitrogen in the plant material. The vision is to implement the method to run automatically in the fertilizer planning system in the whole of Denmark without any extra input from the farmer.

In autumn 2018, *SEGES*, under the sponsorship of the GUDP project SAT-N, took plant cuts to measure the nitrogen uptake in 17 different fields with catch crops and 18 different winter rape fields. The catch crops in Denmark were well-established in many fields and have absorbed a considerably larger amount of nitrogen than normal. In October 2018, there was an exponential correlation found between plant uptake of nitrogen (kg N ha^{-1}) and measured NDVI in catch crops (R^2= 0.51) (Figure 1). NDVI is calculated as follows: NDVI= (NIR − Red) / (NIR + Red), where 'NIR' and 'Red' is the spectral reflectance measurements attained in the visible and near-infrared regions. The NDVI values acquired in this study are the average NDVI values in a specific 10x10 area of a field. NDVI becomes saturated at a high biomass, indicated by NDVI values around 0.8 or higher, therefore the correlation is limited by the NDVI values above 0.8. This occurs because the red light used in NDVI is heavily absorbed by the chlorophyll and the wavelength, which causes difficulty in reaching further down the plant cover than the top leaf layers. This limitation is prevalent in Figure 1, as most NDVI values are greater than 0.8. Furthermore, the variation in NDVI before the saturation point could be due to the type of catch crop or location.

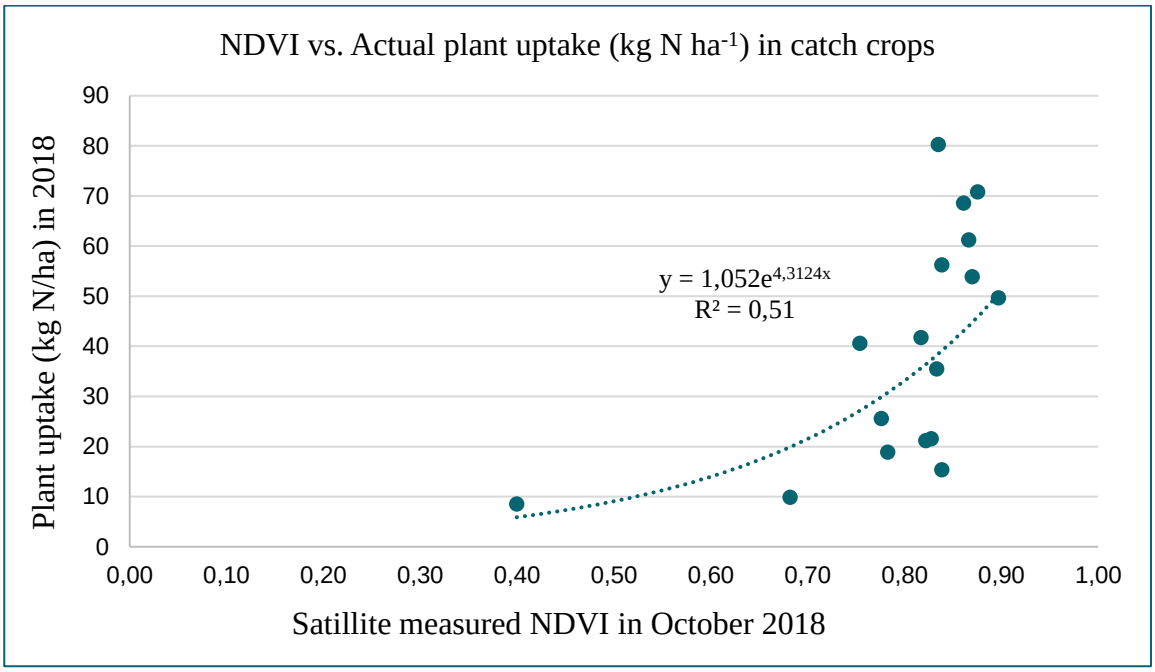

Figure 1. Correlation between plant uptake in kg N ha^{-1} and satellite measured NDVI in October 2018 in catch crops.

No correlation was found between uptake of nitrogen in winter rape and NDVI. Furthermore, in 2019, there was no correlation between measured N-min (0-100 cm) in catch crops and winter rapes, in February, and NDVI in the fall. As previously stated, Denmark had well-developed catch crops in the autumn of 2018, which should attribute to a greater amount of nitrogen in 2019. For heavy catch crops, *SEGES* expected after-effects that were 5-10 kg nitrogen larger than normal, however this varies based on runoff in the autumn. Therefore, the lack of correlation between N-min and NDVI in 2019 could be due to a high precipitation in autumn of 2018 causing leaching of nitrogen not taken up by the crops in autumn.

There is great potential for using NDVI as a measurement parameter for whether a field is vegetated and capable of retaining nutrients. However, NDVI is limited at measurements around 0.8 and greater and, therefore, introduces uncertainty. NDVI is most accurate in the first growth stages, before the plant has excessive foliage. More studies are required to evaluate the use of NDVI to predict field conditions. Due to the uncertainty in the NDVI values, it is evident that more measurements are required before obtaining a concrete conclusion regarding the correlation between plant uptake of nitrogen or N-min and measured NDVI.