

## Analysis of growth and nitrogen uptake of winter oilseed rape before winter using a dynamic crop growth model

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### Introduction

Winter oilseed rape (WOSR) is able to take up large amounts of nitrogen before winter dependent on sowing date, temperatures and the nitrogen supply from the soil. Knowledge of the amount of nitrogen in the canopy before winter is necessary for a more precise estimation of the optimum fertilisation rate in spring (Henke et al. 2009). A model describing all processes of biomass formation and nitrogen uptake could be helpful to extrapolate data collected by means of remote sensing earlier in autumn to the end of growth before winter when measurements are often more difficult. The N uptake before winter then may be used to calculate a site specific N rate. Additionally such a model could be helpful in assessing the need of N fertilisation during autumn and the fate of N fertiliser applied.

An existing crop growth model (Müller 2009) based on the light use efficiency approach was adopted and parameterised in order to simulate the dry matter growth and nitrogen uptake of WOSR sown at different dates and with or without nitrogen fertilisation in autumn. Besides the optimisation of decision support this may help to understand of the processes of biomass formation, nitrogen uptake and accumulation in oilseed rape before winter.

### Material and Methods

A field trial with differentiated sowing date and N fertilisation was conducted in 2009/2010 at the experimental station Hohenschulen near Kiel, Germany. WOSR, variety "Visby", was sown on four dates: 05 August, 18 August, 01 September, and 21 September 2010. For each sowing date there were four N fertilisation amounts (0, 30, 60, 90 kg N ha<sup>-1</sup>) applied shortly after sowing.

At three (for the last sowing date only one) dates between emergence and the end of growth before winter a sample of 1 m<sup>2</sup> was taken and fractioned into leaves, senesced leaves, petioles, and tap root. Green area, dry matter and nitrogen content were measured for all fractions.

A dynamic crop growth model for the vegetative growth of winter oilseed rape was developed, implemented and parameterised by Müller (2009). This model was extended in some aspects especially for autumnal growth and re-parameterised.

The daily dry matter production rate is calculated by the product of absorbed photosynthetic active radiation (PAR) a light use efficiency (LUE) and a temperature factor for photosynthetic activity (fT). The absorbed PAR is dependent on the green area index (GAI) and an extinction coefficient. LUE is dependent on the incoming PAR and is increasing with decreasing PAR.

The produced dry matter is partitioned into shoot and root dry matter where the fraction of dry matter allocated to the root is decreasing with growing degree days since emergence. Shoot dry matter is partitioned into leaves and stems (petioles) following an allometric relationship.

The GAI is calculated from the sum of leaf area index and stem area index, which are derived from leaf dry matter an specific leaf area (SLA) and stem dry matter and specific stem area (SSA), respectively. While SLA is decreasing with growing degree days from emergence, SSA remains constant.

As there is evidence of senescent leaves already before winter without nitrogen deficiency or frost being the cause, a calculation of leaf area loss due to insufficient PAR was included as also discussed by Gabrielle et al. (1998).

The N amounts were calculated for all plant fractions as the product of dry matter and N concentration. The N concentration in leaves is constant while N concentrations in the stem and in the root are decreasing with increasing dry matter.

The plant growth model is coupled with a model of vertical soil water and nitrogen transport using a potential based approach. Therefore the maximal rooting depth was calculated as a linear function of growing degree days since emergence and the vertical distribution of root length densities is calculated according to Kage et al. (2000) decreasing exponentially with soil depth. Water uptake of the plants from the rooted soil layers is then dependent on the potential evapo-transpiration calculated by the Penman-Monteith equation and available water. Likewise, N uptake is calculated by the potential N uptake according to the dry matter growth an available soil mineral N. If there is less N available than the potential uptake, a feed-back reaction reduces the dry matter growth.

Mineralisation of N was estimated by a budget calculation of measured SMN at sowing and before winter as well as measured N in the plants.

The model was parameterised only with data of the variants with sufficient N supply, i.e. the N fertilisation amounts of 60 and 90 kg N/ha. In a second step the variants with less or without N fertilisation were used to parameterise the N deficiency effect on crop growth.

### Results and discussion

The dynamics of dry matter and plant nitrogen amount are simulated by the model quite well for the three first sowing dates and the two higher N fertilisation levels (Table 1) considering that the variation within the data was quite large.

Table 1: Model performance of selected growth parameters for the data set of the first three sowing dates and the two highest fertilisation levels. Given statistical parameters are slope, intercept (with standard error) and coefficient of determination ( $r^2$ ) of the linear regression between the measured and simulated results as well as number of observations (n) and the root mean squared error (RMSE).

	Slope (SE)	Intercept (SE)	$r^2$	n	RMSE
Leaf dry matter [g/m <sup>2</sup> ]	0.84 (±0.074)	7.4 (±5.5)	0.88	18	16.4
Root dry matter [g/m <sup>2</sup> ]	0.68 (±0.131)	2.8 (±4.7)	0.62	18	17.6
Shoot dry matter [g/m <sup>2</sup> ]	0.80 (±0.068)	14.1 (±9.3)	0.89	18	32.7
Green area index [m <sup>2</sup> /m <sup>2</sup> ]	1.17 (±0.067)	-0.04 (±0.07)	0.88	46	0.34
Shoot N amount [g/m <sup>2</sup> ]	1.01 (±0.076)	0.16 (±0.38)	0.92	18	0.97

The effect of N deficiency was not simulated as well leading to a somewhat poorer model performance for the whole data set (not shown). Differences between the fertilisation levels could be reproduced by the model simulation. However, a more precise description of the effects of N deficiencies would need a larger data set. Inclusion of a second year of the trial might increase the model performance.

The N amount taken up by the plants was simulated well with one common parameterisation for all sowing dates (Figure 1). This indicates that the model could be well suited to extrapolate from measured data collected during autumn to the end of growth for fertilisation recommendation purposes.

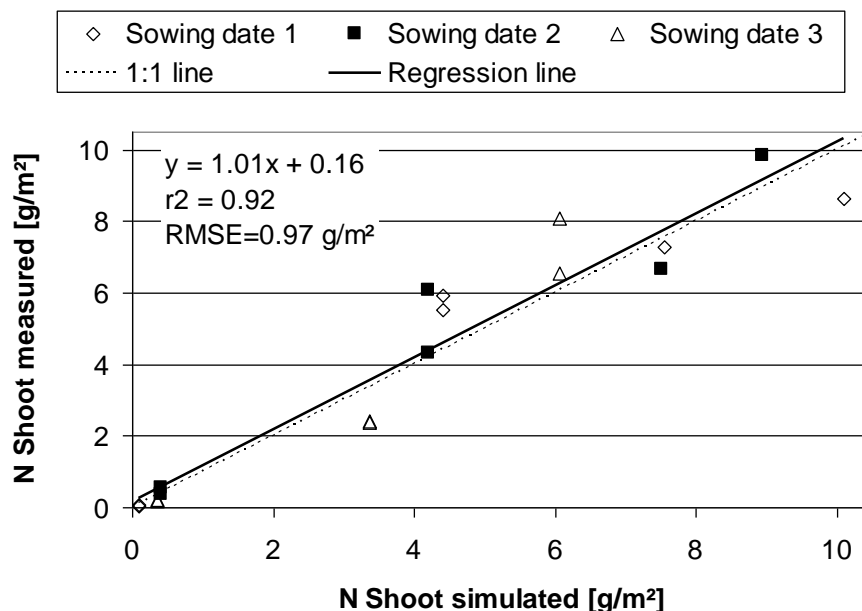


Figure 1: Simulated versus measured N amount in the shoot for the first three sowing dates and the two highest N fertilisation levels.

The model shows that for early sowing dates a large amount of N added by fertiliser can be taken up by the plants (Figure 2). For the first sowing date the calculated potential uptake was even slightly higher than the calculated actual uptake for the highest fertilisation level (90 kg N/ha). At the same time SMN was almost completely depleted. In contrast, the simulated potential N uptake for the third

sowing date was much lower, the highest fertilised N amount could not be taken up by the plants and a large amount of SMN was left in the soil which is potentially at risk of leaching during winter. The measured data support this conclusion although the variation within the plant samples was very large, especially at the last sampling date before winter.

To what extent a higher N uptake due to N fertilisation might be relevant for the growth in spring and for yield formation should be investigated further. An extension of the model for spring growth and yield formation can support these investigations.

SMN might be simulated better by inclusion of a process based mineralisation model. However, the presented data set is not sufficient for a robust parameterisation. Additional data from different trials at the same location should be used for this purpose.

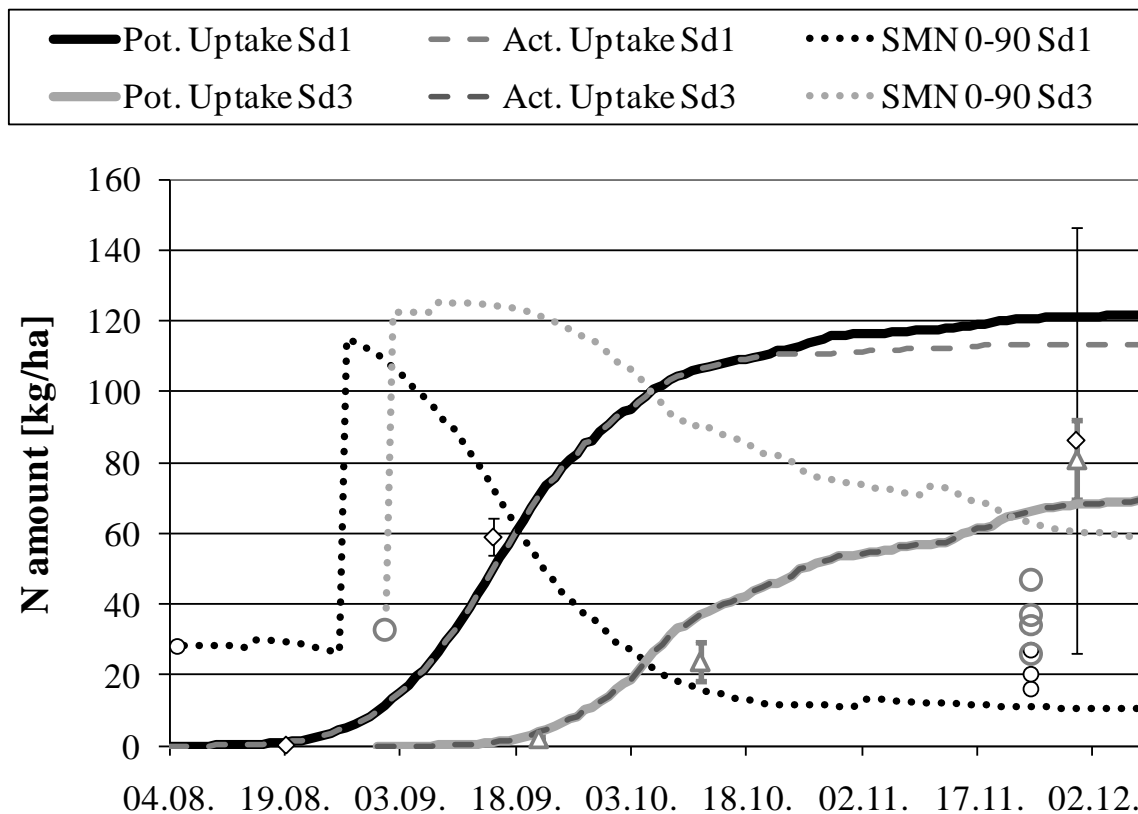


Figure 2: Simulated time course of potential and actual N uptake for the highest fertilisation level and first (Sd1) and third sowing date (Sd3) as well as SMN for 0 to 90 cm soil depth. Measured data of actual N uptake (Sd1: diamonds, Sd3: triangles) are shown with error bars while the individual SMN measurements at the end of plant growth before winter are shown (circles).

### Conclusions

The presented model can be a helpful tool to estimate the dynamics of N uptake by WOSR during the autumnal growth. It can give a calculation of the maximum N amount that can be taken up by the crop taken an assumed projection of temperature and PAR into account. This can help to avoid N fertilisation that could increase the risk of N leaching. Furthermore the model allows for extrapolation of measured data to the end of growth before winter if weather conditions prevent late measurements for example by reflexion spectrometry.

### References

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